

### **Gaussian mixture models for signal mapping and positioning**

Maps of RSS from a wireless transmitter can be used for positioning or for planning wireless infrastructure. The RSS values measured at a single point are not always the same, but follow some distribution, which vary from point to point. In existing approaches in the literature this variation is neglected or its mapping requires making many measurements at every point, which makes the measurement collection very laborious. We propose to use GMs for modeling joint distributions of the position and the RSS value. The proposed model is more versatile than methods found in the literature as it models the joint distribution of RSS measurements and the location space. This allows us to model the distributions of RSS values in every point of space without making many measurement in every point. In addition, GMs allow us to compute conditional probabilities and posteriors of position in closed form. The proposed models can model any RSS attenuation pattern, which is useful for positioning in multifloor buildings. Our tests with WLAN signals show that positioning with the proposed algorithm provides accurate position estimates. We conclude that the proposed algorithm can provide useful information about distributions of RSS values for different applications.

#### **General information**

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MoE publication type: A1 Journal article-refereed

Organisations: Computing Sciences, Research group: Automation and Systems Theory, Aalto University, University of Liverpool, Universidad Antonio de Nebrija, Uppsala University

Contributors: Raitoharju, M., García-Fernández, F., Hostettler, R., Piché, R., Särkkä, S.

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Keywords: Gaussian mixtures, Indoor positioning, RSS, Signal mapping, Statistical modeling

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Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### **Fusion enhancement for tracking of respiratory rate through intrinsic mode functions in photoplethysmography**

Decline in respiratory regulation demonstrates the primary forewarning for the onset of physiological aberrations. In clinical environment, the obtrusive nature and cost of instrumentation have retarded the integration of continuous respiration monitoring for standard practice. Photoplethysmography (PPG) presents a non-invasive, optical method of assessing blood flow dynamics in peripheral vasculature. Incidentally, respiration couples as a surrogate constituent in PPG signal, justifying respiratory rate (RR) estimation. The physiological processes of respiration emerge as distinctive oscillations that are fluctuations in various parameters extracted from PPG signal. We propose a novel algorithm designed to account for intermittent diminishment of the respiration induced variabilities (RIV) by a fusion-based enhancement of wavelet synchrosqueezed spectra. We have combined the information on intrinsic mode functions (IMF) of five RIVs to enhance mutually occurring, instantaneous frequencies of the spectra. The respiration rate estimate is obtained by tracking the spectral ridges with a particle filter. We have evaluated the method with a dataset recorded from 29 young adult subjects (mean: 24.17 y, SD: 4.19 y) containing diverse, voluntary, and periodically metronome-assisted respiratory patterns. Bayesian inference on fusion-enhanced Respiration Induced Frequency Variability (RIFV) indicated MAE and RMSE of 1.764 and 3.996 BPM, respectively. The fusion approach was deemed to improve MAE and RMSE of RIFV by 0.185 BPM (95% HDI: 0.0285-0.3488, effect size: 0.548) and 0.250 BPM (95% HDI: 0.0733-0.431, effect size: 0.653), respectively, with further pronounced improvements to other RIVs. We conclude that the fusion of variability signals proves important to IMF localization in the spectral estimation of RR.

#### **General information**

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Organisations: BioMediTech, Research group: Sensor Technology and Biomeasurements (STB)

Contributors: Pirhonen, M., Vehkaoja, A.

Number of pages: 11

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ISSN (Print): 1746-8094

Original language: English

ASJC Scopus subject areas: Signal Processing, Health Informatics

Keywords: Particle filtering, Photoplethysmography, Respiration rate, Spectral fusion, Synchrosqueezing

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#### Bibliographical note

INT=bmte,"Pirhonen, Mikko"

Source: Scopus

Source ID: 85079696106

Research output: Contribution to journal > Article > Scientific > peer-review

#### Online Spectrogram Inversion for Low-Latency Audio Source Separation

Audio source separation is usually achieved by estimating the short-time Fourier transform (STFT) magnitude of each source, and then applying a spectrogram inversion algorithm to retrieve time-domain signals. In particular, the multiple input spectrogram inversion (MISI) algorithm has been exploited successfully in several recent works. However, this algorithm suffers from two drawbacks, which we address in this letter. First, it has originally been introduced in a heuristic fashion: we propose here a rigorous optimization framework in which MISI is derived, thus proving the convergence of this algorithm. Besides, while MISI operates offline, we propose here an online version of MISI called oMISI, which is suitable for low-latency source separation, an important requirement for e.g., hearing aids applications. oMISI also allows one to use alternative phase initialization schemes exploiting the temporal structure of audio signals. Experiments conducted on a speech separation task show that oMISI performs as well as its offline counterpart, thus demonstrating its potential for real-time source separation.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research group: Audio research group - ARG, Computing Sciences, University of Toulouse, INP, LAAS-CNRS

Contributors: Magron, P., Virtanen, T.

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Pages: 306-310

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Peer-reviewed: Yes

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Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering, Applied Mathematics

Keywords: Audio source separation, low-latency, online spectrogram inversion, phase recovery, sinusoidal modeling

DOIs:

10.1109/LSP.2020.2970310

#### Bibliographical note

EXT="Magron, Paul"

Source: Scopus

Source ID: 85080104357

Research output: Contribution to journal > Article > Scientific > peer-review

#### Functional electrical stimulation for facial pacing: Effects of waveforms on movement intensity and ratings of discomfort

Facial pacing systems aim to reanimate paralyzed facial muscles with electrical stimulation. To aid the development of such systems, the frontalis muscle responsible for eyebrow raising was transcutaneously stimulated in 12 healthy participants using four waveforms: square wave, square wavelet, sine wave, and sinusoidal wavelet. The aim was to investigate the effects of the waveform on muscle activation magnitude, perceived discomfort, and the relationship

between the stimulus signal amplitude and the magnitude of evoked movement. The magnitude of movement was measured offline using video recordings and compared to the magnitude of maximum voluntary movement (MVM) of eyebrows. Results showed that stimulations evoked forehead movement at a magnitude comparable to the MVM in 67% of the participants and close to comparable (80% of the MVM) in 92%. All the waveforms were equally successful in evoking movements. Perceived discomfort did not differ between the waveforms in relation to the movement magnitude, but some individual preferences did exist. Further, regression analysis showed a statistically significant linear relation between stimulation amplitudes and the evoked movement in 98% of the cases. As the waveforms performed equally well in evoking muscle activity, the waveform in pacing systems could be selected by emphasizing technical aspects such as the possibility to suppress stimulation artifacts from simultaneous electromyography measurement.

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Organisations: Research group: Sensor Technology and Biomeasurements (STB), BioMediTech, Tampere University, Tampere University Hospital

Contributors: Ilves, M., Rantanen, V., Venesvirta, H., Lylykangas, J., Vehkaoja, A., Mäkelä, E., Verho, J., Lekkala, J., Rautiainen, M., Surakka, V.

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ASJC Scopus subject areas: Signal Processing, Health Informatics

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#### **Bibliographical note**

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Source: Scopus

Source ID: 85084080389

Research output: Contribution to journal > Article > Scientific > peer-review

#### **Compressive sensed video recovery via iterative thresholding with random transforms**

The authors consider the problem of compressive sensed video recovery via iterative thresholding algorithm. Traditionally, it is assumed that some fixed sparsifying transform is applied at each iteration of the algorithm. In order to improve the recovery performance, at each iteration the thresholding could be applied for different transforms in order to obtain several estimates for each pixel. Then the resulting pixel value is computed based on obtained estimates using simple averaging. However, calculation of the estimates leads to significant increase in reconstruction complexity. Therefore, the authors propose a heuristic approach, where at each iteration only one transform is randomly selected from some set of transforms. First, they present simple examples, when block-based 2D discrete cosine transform is used as the sparsifying transform, and show that the random selection of the block size at each iteration significantly outperforms the case when fixed block size is used. Second, building on these simple examples, they apply the proposed approach when video block-matching and 3D filtering (VBM3D) is used for the thresholding and show that the random transform selection within VBM3D allows to improve the recovery performance as compared with the recovery based on VBM3D with fixed transform.

#### **General information**

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MoE publication type: A1 Journal article-refereed

Organisations: Computing Sciences, Research group: Computational Imaging-CI, ITMO University, Linköping University, University of Oulu

Contributors: Belyaev, E., Codreanu, M., Juntti, M., Egiazarian, K.

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ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Electrical and Electronic Engineering

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10.1049/iet-ipr.2019.0661

### **Bibliographical note**

EXT="Belyaev, Evgeny"

Source: Scopus

Source ID: 85084175769

Research output: Contribution to journal > Article > Scientific > peer-review

### **Vehicle Attribute Recognition by Appearance: Computer Vision Methods for Vehicle Type, Make and Model Classification**

This paper studies vehicle attribute recognition by appearance. In the literature, image-based target recognition has been extensively investigated in many use cases, such as facial recognition, but less so in the field of vehicle attribute recognition. We survey a number of algorithms that identify vehicle properties ranging from coarse-grained level (vehicle type) to fine-grained level (vehicle make and model). Moreover, we discuss two alternative approaches for these tasks, including straightforward classification and a more flexible metric learning method. Furthermore, we design a simulated real-world scenario for vehicle attribute recognition and present an experimental comparison of the two approaches.

### **General information**

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MoE publication type: A1 Journal article-refereed

Organisations: Computing Sciences, Research group: Multimedia Research Group - MRG

Contributors: Ni, X., Huttunen, H.

Publication date: 2020

Peer-reviewed: Yes

### **Publication information**

Journal: Journal of Signal Processing Systems

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ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

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URLs:

<http://urn.fi/URN:NBN:fi:tuni-202007076341>

Source: Scopus

Source ID: 85086837300

Research output: Contribution to journal > Article > Scientific > peer-review

### **Digital Predistortion for Multiuser Hybrid MIMO at mmWaves**

Efficient mitigation of power amplifier (PA) nonlinear distortion in multi-user hybrid precoding based broadband mmWave systems is an open research problem. In this article, we carry out detailed signal and distortion modeling in broadband multi-user hybrid MIMO systems, with a bank of nonlinear PAs in each subarray, while also take the inevitable crosstalk between the antenna/PA branches into account. Building on the derived models, we adopt and describe an efficient closed-loop (CL) digital predistortion (DPD) solution that utilizes only a single-input DPD unit per transmit chain or subarray, despite crosstalk, providing thus substantial complexity-benefit compared to the state-of-the-art multi-dimensional DPD solutions. We show that under spatially correlated multipath propagation, each single-input DPD unit can provide linearization towards every intended user, or more generally, towards all spatial directions where coherent propagation is taking place, and that the adopted CL DPD system is robust against crosstalk. Extensive numerical results building on practical measurement-based mmWave PA models are provided, demonstrating and verifying the excellent linearization performance of the overall DPD system in different evaluation scenarios.

### **General information**

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MoE publication type: A1 Journal article-refereed

Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning, Zewail City of Science and Technology, Chalmers University of Technology, Lunds Universitet / Lunds Tekniska Högskola

Contributors: Brihuega, A., Anttila, L., Abdelaziz, M., Eriksson, T., Tufvesson, F., Valkama, M.  
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Pages: 3603-3618  
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Keywords: Crosstalk, digital predistortion, hybrid MIMO, large-array transmitters, millimeter wave communications, multi-user MIMO, nonlinear distortion, out-of-band emissions, power amplifiers

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URLs:

<http://urn.fi/URN:NBN:fi:tuni-202009307195>

#### Bibliographical note

EXT="Abdelaziz, Mahmoud"

Source: Scopus

Source ID: 85087520842

Research output: Contribution to journal > Article > Scientific > peer-review

#### Multimodal subspace support vector data description

In this paper, we propose a novel method for projecting data from multiple modalities to a new subspace optimized for one-class classification. The proposed method iteratively transforms the data from the original feature space of each modality to a new common feature space along with finding a joint compact description of data coming from all the modalities. For data in each modality, we define a separate transformation to map the data from the corresponding feature space to the new optimized subspace by exploiting the available information from the class of interest only. We also propose different regularization strategies for the proposed method and provide both linear and non-linear formulations. The proposed Multimodal Subspace Support Vector Data Description outperforms all the competing methods using data from a single modality or fusing data from all modalities in four out of five datasets.

#### General information

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MoE publication type: A1 Journal article-refereed

Organisations: Computing Sciences, Research group: Multimedia Research Group - MRG, Finnish Environment Institute, Aarhus Universitet

Contributors: Sohrab, F., Raitoharju, J., Iosifidis, A., Gabbouj, M.

Number of pages: 13

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Peer-reviewed: Yes

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ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Artificial Intelligence

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10.1016/j.patcog.2020.107648

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#### Bibliographical note

EXT="Iosifidis, Alexandros"

Source: Scopus

Source ID: 85090954677

Research output: Contribution to journal › Article › Scientific › peer-review

### **Self-Supervised Light Field Reconstruction Using Shearlet Transform and Cycle Consistency**

Shearlet Transform (ST) has been instrumental for the Densely-Sampled Light Field (DSLRF) reconstruction, as it sparsifies the underlying Epipolar-Plane Images (EPIs). The sought sparsification is implemented through an iterative regularization, which tends to be slow because of the time spent on domain transformations for dozens of iterations. To overcome this limitation, this letter proposes a novel self-supervised DSLRF reconstruction method, CycleST, which employs ST and cycle consistency. Specifically, CycleST is composed of an encoder-decoder network and a residual learning strategy that restore the shearlet coefficients of densely-sampled EPIs using EPI-reconstruction and cycle-consistency losses. CycleST is a self-supervised approach that can be trained solely on Sparsely-Sampled Light Fields (SSLFs) with small disparity ranges ( 8 pixels). Experimental results of DSLRF reconstruction on SSLFs with large disparity ranges (16-32 pixels) demonstrate the effectiveness and efficiency of the proposed CycleST method. Furthermore, CycleST achieves ~ 9x speedup over ST, at least.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Computing Sciences, Research group: 3D MEDIA

Contributors: Gao, Y., Bregovic, R., Gotchev, A.

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Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering, Applied Mathematics

Keywords: cycle consistency, Image-based rendering, light field reconstruction, self-supervision, shearlet transform

DOIs:

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Source: Scopus

Source ID: 85091167231

Research output: Contribution to journal › Article › Scientific › peer-review

### **Bayesian receiver operating characteristic metric for linear classifiers**

We propose a novel classifier accuracy metric: the Bayesian Area Under the Receiver Operating Characteristic Curve (CBAUC). The method estimates the area under the ROC curve and is related to the recently proposed Bayesian Error Estimator. The metric can assess the quality of a classifier using only the training dataset without the need for computationally expensive cross-validation. We derive a closed-form solution of the proposed accuracy metric for any linear binary classifier under the Gaussianity assumption, and study the accuracy of the proposed estimator using simulated and real-world data. These experiments confirm that the closed-form CBAUC is both faster and more accurate than conventional AUC estimators.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research group: Computational Systems Biology, Computing Sciences, AI Virtanen Institute for Molecular Sciences, University of Eastern Finland

Contributors: Hassan, S. S., Huttunen, H., Niemi, J., Tohka, J.

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Original language: English

ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Artificial Intelligence

Keywords: Bayesian error estimation, Classification, Receiver operating characteristic curve

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10.1016/j.patrec.2019.07.016

### **Bibliographical note**

EXT="Tohka, Jussi"

Source: Scopus

Source ID: 85071016385

Research output: Contribution to journal › Article › Scientific › peer-review

### **Generalization of the K-SVD algorithm for minimization of $\beta$ -divergence**

In this paper, we propose, describe, and test a modification of the K-SVD algorithm. Given a set of training data, the proposed algorithm computes an overcomplete dictionary by minimizing the  $\beta$ -divergence ( $\beta \geq 1$ ) between the data and its representation as linear combinations of atoms of the dictionary, under strict sparsity restrictions. For the special case  $\beta=2$ , the proposed algorithm minimizes the Frobenius norm and, therefore, for  $\beta=2$  the proposed algorithm is equivalent to the original K-SVD algorithm. We describe the modifications needed and discuss the possible shortcomings of the new algorithm. The algorithm is tested with random matrices and with an example based on speech separation.

### **General information**

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Organisations: Computing Sciences, Universitat Politècnica de València

Contributors: Garcia-Molla, V. M., San Juan, P., Virtanen, T., Vidal, A. M., Alonso, P.

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Publication date: 1 Sep 2019

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### **Publication information**

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Scopus rating (2019): CiteScore 5.5 SJR 0.659 SNIP 1.558

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Beta-divergence, K-SVD, Matching pursuit algorithms, NMF, Nonnegative K-SVD

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Source: Scopus

Source ID: 85065411279

Research output: Contribution to journal › Article › Scientific › peer-review

### **An approval of MPPT based on pv cell's simplified equivalent circuit during fast-shading conditions**

The partial shading conditions significantly affect the functionality of solar power plants despite the presence of multiple maximum power point tracking systems. The primary cause of this problem is the presence of local maxima in the power-current and/or power-voltage characteristic curves that restrict the functionality of the conventional maximum power point tracking systems. The present article proposes a modified algorithm based on the simplified equivalent circuit of solar cells to improve the functionality of traditional maximum power point tracking systems. This algorithm provides a method for regularly monitoring the photo-current of each solar module. The upper and lower boundaries of the regulating parameter such as current or voltage are decided very precisely, which is helpful to find the location of the global maximum. During a sequential search, the control system accurately determines the lower and upper boundaries of the global maximum. Simultaneously, the maximum power point tracking system increases the photovoltaic current up to one of these boundaries and applies one of the conventional algorithms. Additionally, the control system regularly monitors the photovoltaic characteristics and changes the limits of regulating parameter concerning any change in global maximum location. This proposed method is fast and precise to locate the global maximum boundaries and to track global maximum even under fast-changing partial shading conditions. The improved performance and overall efficiency are validated by simulation study for variable solar irradiance.

### **General information**

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Organisations: Automation Technology and Mechanical Engineering, Ariel University Center of Samaria  
Contributors: Rajput, S., Averbukh, M., Yahalom, A., Minav, T.  
Number of pages: 14  
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Peer-reviewed: Yes

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Issue number: 9

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Ratings:

Scopus rating (2019): CiteScore 1.9 SJR 0.303 SNIP 1.088

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Signal Processing, Hardware and Architecture, Computer Networks and Communications, Electrical and Electronic Engineering

Keywords: Equivalent circuit, Global maximum, Maximum power point tracking, Partial shading, Photovoltaic system, Solar module

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Research output: Contribution to journal > Article > Scientific > peer-review

#### Performance analysis of single-query 6-DoF camera pose estimation in self-driving setups

In this work, we consider the problem of single-query 6-DoF camera pose estimation, i.e. estimating the position and orientation of a camera by using reference images and a point cloud. We perform a systematic comparison of three state-of-the-art strategies for 6-DoF camera pose estimation: feature-based, photometric-based and mutual-information-based approaches. Two standard datasets with self-driving setups are used for experiments, and the performance of the studied methods is evaluated in terms of success rate, translation error and maximum orientation error. Building on the analysis of the results, we evaluate a hybrid approach that combines feature-based and mutual-information-based pose estimation methods to benefit from their complementary properties for pose estimation. Experiments show that (1) in cases with large appearance change between query and reference, the hybrid approach outperforms feature-based and mutual-information-based approaches by an average increment of 9.4% and 8.7% in the success rate, respectively; (2) in cases where query and reference images are captured at similar imaging conditions, the hybrid approach performs similarly as the feature-based approach, but outperforms both photometric-based and mutual-information-based approaches with a clear margin; (3) the feature-based approach is consistently more accurate than mutual-information-based and photometric-based approaches when at least 4 consistent matching points are found between the query and reference images.

#### General information

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Organisations: Computing Sciences, Universidad Industrial de Santander, Czech Technical University in Prague

Contributors: Fu, J., Pertuz, S., Matas, J., Kämäräinen, J.

Pages: 58-73

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ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition

Keywords: 3D point cloud, Camera pose estimation, Hybrid method, Mutual information, Photometric matching, Self driving car



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10.1016/j.cviu.2019.04.009

### **Bibliographical note**

EXT="Matas, Jiri"

Source: Scopus

Source ID: 85067195521

Research output: Contribution to journal › Article › Scientific › peer-review

### **Design and implementation of a multi-sensor newborn EEG seizure and background model with inter-channel field characterization**

This paper presents a novel multi-sensor non-stationary EEG model; it is obtained by combining state of the art mono-sensor newborn EEG simulators, a multilayer newborn head model comprised of four homogeneous concentric spheres, a multi-sensor propagation scheme based on array processing and optical dispersion to calculate inter-channel attenuation and delay, and lastly, a multi-variable optimization paradigm using particle swarm optimization and Monte-Carlo simulations to validate the model for optimal conditions. Multi-sensor EEG of 7 newborns, comprised of seizure and background epochs, are analyzed using time-space, time-frequency, power maps and multi-sensor causality techniques. The outcomes of these methods are validated by medical insights and serve as a backbone for any assumptions and as performance benchmarks for the model to be evaluated against. The results obtained with the developed model show 85.7% averaged time-frequency correlation (which is the selected measure for similarity with real EEG) with 5.9% standard deviation, and the averaged error obtained is 34.6% with 8% standard deviation. The resulting performances indicate that the proposed model provides a suitable matching fit with real EEG in terms of their probability density function, inter-sensor attenuation and translation, and multi-sensor causality. They also demonstrate the model flexibility to generate new unseen samples by utilizing user-defined parameters, making it suitable for other relevant applications.

### **General information**

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MoE publication type: A1 Journal article-refereed

Organisations: Computing Sciences, Qatar University, University of Queensland

Contributors: Al-Sa'd, M. F., Boashash, B.

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ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: EEG analysis, Multi-channel EEG, Multi-sensor propagation, Time-frequency processing, Time-space analysis

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Source: Scopus

Source ID: 85065143207

Research output: Contribution to journal › Article › Scientific › peer-review

### **Socially inspired relaying and proactive mode selection in mmWave vehicular communications**

As the Internet of Vehicles matures and acquires its social flavor, novel wireless connectivity enablers are being demanded for reliable data transfer in high-rate applications. The recently ratified New Radio communications technology operates in millimeter-wave (mmWave) spectrum bands and offers sufficient capacity for bandwidth-hungry services. However, seamless operation over mmWave is difficult to maintain on the move, since such extremely high frequency radio links are susceptible to unexpected blockage by various obstacles, including vehicle bodies. As a result, proactive mode selection, that is, migration from infrastructure- to vehicle-based connections and back, is becoming vital to avoid blockage situations. Fortunately, the very social structure of interactions between the neighboring smart cars and their passengers may be leveraged to improve session continuity by relaying data via proximate vehicles. This paper conceptualizes the socially inspired relaying scenarios, conducts underlying mathematical analysis, continues with a detailed 3-D modeling to facilitate proactive mode selection, and concludes by discussing a practical prototype of a vehicular mmWave platform.

### **General information**

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Organisations: Electrical Engineering, University of California, Los Angeles  
Contributors: Moltchanov, D., Kovalchukov, R., Gerasimenko, M., Andreev, S., Koucheryavy, Y., Gerla, M.  
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Original language: English  
ASJC Scopus subject areas: Signal Processing, Information Systems, Hardware and Architecture, Computer Science Applications, Computer Networks and Communications  
Keywords: Internet of Things, Millimeter wave (mmWave) communication, Social network services, Vehicular ad hoc networks  
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Socially-Inspired Relaying 2019  
DOIs:  
10.1109/JIOT.2019.2898420  
URLs:  
<http://urn.fi/URN:NBN:fi:tuni-202001311720>  
Source: Scopus  
Source ID: 85067875266  
Research output: Contribution to journal > Article > Scientific > peer-review

#### Deep Learning for Audio Signal Processing

Given the recent surge in developments of deep learning, this paper provides a review of the state-of-the-art deep learning techniques for audio signal processing. Speech, music, and environmental sound processing are considered side-by-side, in order to point out similarities and differences between the domains, highlighting general methods, problems, key references, and potential for cross fertilization between areas. The dominant feature representations (in particular, log-mel spectra and raw waveform) and deep learning models are reviewed, including convolutional neural networks, variants of the long short-term memory architecture, as well as more audio-specific neural network models. Subsequently, prominent deep learning application areas are covered, i.e., audio recognition (automatic speech recognition, music information retrieval, environmental sound detection, localization and tracking) and synthesis and transformation (source separation, audio enhancement, generative models for speech, sound, and music synthesis). Finally, key issues and future questions regarding deep learning applied to audio signal processing are identified.

#### General information

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Computing Sciences, Aalborg University, Google Inc, University of Toulon, Austrian Research Institute for Artificial Intelligence  
Contributors: Purwins, H., Li, B., Virtanen, T., Schlüter, J., Chang, S. Y., Sainath, T.  
Number of pages: 14  
Pages: 206-219  
Publication date: 1 May 2019  
Peer-reviewed: Yes

#### Publication information

Journal: IEEE Journal on Selected Topics in Signal Processing  
Volume: 13  
Issue number: 2  
ISSN (Print): 1932-4553  
Ratings:  
Scopus rating (2019): CiteScore 14.8 SJR 2.202 SNIP 3.123  
Original language: English  
ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering  
Keywords: audio enhancement, automatic speech recognition, connectionist temporal memory, Deep learning, environmental sounds, music information retrieval, source separation

DOIs:

10.1109/JSTSP.2019.2908700

Source: Scopus

Source ID: 85065962111

Research output: Contribution to journal › Article › Scientific › peer-review

### **Convolutional low-resolution fine-grained classification**

Successful fine-grained image classification methods learn subtle details between visually similar (sub-)classes, but the problem becomes significantly more challenging if the details are missing due to low resolution. Encouraged by the recent success of Convolutional Neural Network (CNN) architectures in image classification, we propose a novel resolution-aware deep model which combines convolutional image super-resolution and convolutional fine-grained classification into a single model in an end-to-end manner. Extensive experiments on multiple benchmarks demonstrate that the proposed model consistently performs better than conventional convolutional networks on classifying fine-grained object classes in low-resolution images.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Research group: Vision

Contributors: Cai, D., Chen, K., Qian, Y., Kämäräinen, J.

Pages: 166-171

Publication date: Mar 2019

Peer-reviewed: Yes

Early online date: 2017

### **Publication information**

Journal: Pattern Recognition Letters

Volume: 119

ISSN (Print): 0167-8655

Ratings:

Scopus rating (2019): CiteScore 6.3 SJR 0.848 SNIP 2.021

Original language: English

ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Artificial Intelligence

Keywords: Deep learning, Fine-grained image classification, Super resolution convolutional neural networks

DOIs:

10.1016/j.patrec.2017.10.020

Source: Scopus

Source ID: 85032974725

Research output: Contribution to journal › Article › Scientific › peer-review

### **ALMARVI System Solution for Image and Video Processing in Healthcare, Surveillance and Mobile Applications**

ALMARVI is a collaborative European research project funded by Artemis involving 16 industrial as well as academic partners across 4 countries, working together to address various computational challenges in image and video processing in 3 application domains: healthcare, surveillance and mobile. This paper is an editorial for a special issue discussing the integrated system created by the partners to serve as a cross-domain solution for the project. The paper also introduces the partner articles published in this special issue to discuss the various technological developments achieved within ALMARVI spanning all system layers, from hardware to applications. We illustrate the challenges faced within the project based on use cases from the three targeted application domains, and how these can address the 4 main project objectives addressing 4 challenges faced by high performance image and video processing systems: massive data rate, low power consumption, composability and robustness. We present a system stack composed of algorithms, design frameworks and platforms as a solution to these challenges. Finally, the use cases from the three different application domains are mapped on the system stack solution and are evaluated based on their performance for each of the 4 ALMARVI objectives.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Pervasive Computing, Delft University of Technology, Philips Healthcare Nederland

Contributors: Al-Ars, Z., van der Vlugt, S., Jääskeläinen, P., van der Linden, F.

Pages: 1-7

Publication date: Jan 2019

Peer-reviewed: Yes

Early online date: 2018

### Publication information

Journal: Journal of Signal Processing Systems

Volume: 91

Issue number: 1

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2019): CiteScore 2.4 SJR 0.298 SNIP 0.833

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

DOIs:

10.1007/s11265-018-1423-2

Source: Scopus

Source ID: 85057058836

Research output: Contribution to journal > Article > Scientific > peer-review

### Video coding of dynamic 3D point cloud data

Due to the increased popularity of augmented (AR) and virtual (VR) reality experiences, the interest in representing the real world in an immersive fashion has never been higher. Distributing such representations enables users all over the world to freely navigate in never seen before media experiences. Unfortunately, such representations require a large amount of data, not feasible for transmission on today's networks. Thus, efficient compression technologies are in high demand. This paper proposes an approach to compress 3D video data utilizing 2D video coding technology. The proposed solution was developed to address the needs of "tele-immersive" applications, such as VR, AR, or mixed reality with "Six Degrees of Freedom" capabilities. Volumetric video data is projected on 2D image planes and compressed using standard 2D video coding solutions. A key benefit of this approach is its compatibility with readily available 2D video coding infrastructure. Furthermore, objective and subjective evaluation shows significant improvement in coding efficiency over reference technology. The proposed solution was contributed and evaluated in international standardization. Although it is was not selected as the winning proposal, as very similar solution has been selected developed since then.

### General information

Publication status: E-pub ahead of print

MoE publication type: A1 Journal article-refereed

Organisations: Computing Sciences, Nokia Technologies

Contributors: Schwarz, S., Shekipour, N., Fakour Sevom, V., Hannuksela, M. M.

Number of pages: 12

Publication date: 2019

Peer-reviewed: Yes

### Publication information

Journal: APSIPA Transactions on Signal and Information Processing

Article number: e31

ISSN (Print): 2048-7703

Ratings:

Scopus rating (2019): CiteScore 2.1 SJR 0.251 SNIP 0.655

Original language: English

ASJC Scopus subject areas: Signal Processing, Information Systems

Keywords: AR, Immersive media, Point cloud coding, Volumetric video

Electronic versions:

video\_coding\_of\_dynamic\_3d\_point\_cloud\_data

DOIs:

10.1017/ATSIP.2019.24

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202001171369>

Source: Scopus

Source ID: 85076929574

Research output: Contribution to journal > Article > Scientific > peer-review

### Digital Predistortion for 5G Small Cell: GPU Implementation and RF Measurements

In this paper, we present a high data rate implementation of a digital predistortion (DPD) algorithm on a modern mobile multicore CPU containing an on-chip GPU. The proposed implementation is capable of running in real-time, thanks to the execution of the predistortion stage inside the GPU, and the execution of the learning stage on a separate CPU core. This configuration, combined with the low complexity DPD design, allows for more than 400 Msamples/s sample rates. This is sufficient for satisfying 5G new radio (NR) base station radio transmission specifications in the sub-6 GHz bands, where signal bandwidths up to 100 MHz are specified. The linearization performance is validated with RF measurements on two

base station power amplifiers at 3.7 GHz, showing that the 5G NR downlink emission requirements are satisfied.

#### General information

Publication status: E-pub ahead of print

MoE publication type: A1 Journal article-refereed

Organisations: Electrical Engineering, Computing Sciences, Research area: Computer engineering, Research group: Wireless Communications and Positioning, University of Vaasa (UVA), Tampere University

Contributors: Pascual Campo, P., Lampu, V., Meirhaeghe, A., Boutellier, J., Anttila, L., Valkama, M.

Number of pages: 12

Publication date: 2019

Peer-reviewed: Yes

#### Publication information

Journal: Journal of Signal Processing Systems

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2019): CiteScore 2.4 SJR 0.298 SNIP 0.833

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: 5G, Digital predistortion (DPD), GPU, High data rate, Real-time

Electronic versions:

PascualCampo2019\_Article\_DigitalPredistortionFor5GSmall

DOIs:

10.1007/s11265-019-01502-4

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202001171372>

#### Bibliographical note

INT=comp,"Meirhaeghe, Alexandre"

Source: Scopus

Source ID: 85077054281

Research output: Contribution to journal > Article > Scientific > peer-review

#### Cascade of Boolean detector combinations

This paper considers a scenario when we have multiple pre-trained detectors for detecting an event and a small dataset for training a combined detection system. We build the combined detector as a Boolean function of thresholded detector scores and implement it as a binary classification cascade. The cascade structure is computationally efficient by providing the possibility to early termination. For the proposed Boolean combination function, the computational load of classification is reduced whenever the function becomes determinate before all the component detectors have been utilized. We also propose an algorithm, which selects all the needed thresholds for the component detectors within the proposed Boolean combination. We present results on two audio-visual datasets, which prove the efficiency of the proposed combination framework. We achieve state-of-the-art accuracy with substantially reduced computation time in laughter detection task, and our algorithm finds better thresholds for the component detectors within the Boolean combination than the other algorithms found in the literature.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing

Contributors: Mahkonen, K., Virtanen, T., Kämäräinen, J.

Publication date: Dec 2018

Peer-reviewed: Yes

#### Publication information

Journal: Eurasip Journal on Image and Video Processing

Volume: 2018

Article number: 61

ISSN (Print): 1687-5176

Ratings:

Scopus rating (2018): CiteScore 2.2 SJR 0.342 SNIP 1.086

Original language: English

ASJC Scopus subject areas: Signal Processing, Information Systems, Electrical and Electronic Engineering

Keywords: Binary classification, Boolean combination, Classification cascade

Electronic versions:

Cascade of Boolean detector combinations

DOIs:

10.1186/s13640-018-0303-9

URLs:

<http://urn.fi/URN:NBN:fi:tty-201808072054>

Source: Scopus

Source ID: 85050598957

Research output: Contribution to journal > Article > Scientific > peer-review

### **Toward Efficient Execution of RVC-CAL Dataflow Programs on Multicore Platforms**

The increasing number of cores in System on Chips (SoC) has introduced challenges in software parallelization. As an answer to this, the dataflow programming model offers a concurrent and reusability promoting approach for describing applications. In this work, a runtime for executing Dataflow Process Networks (DPN) on multicore platforms is proposed. The main difference between this work and existing methods is letting the operating system perform Central processing unit (CPU) load-balancing freely, instead of limiting thread migration between processing cores through CPU affinity. The proposed runtime is benchmarked on desktop and server multicore platforms using five different applications from video coding and telecommunication domains. The results show that the proposed method offers significant improvements over the state-of-art, in terms of performance and reliability.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Pervasive Computing, Research area: Computer engineering, Univ of Oulu

Contributors: Hautala, I., Boutellier, J., Nyländén, T., Silvén, O.

Number of pages: 11

Pages: 1507-1517

Publication date: Nov 2018

Peer-reviewed: Yes

Early online date: 9 Feb 2018

#### **Publication information**

Journal: Journal of Signal Processing Systems

Volume: 90

Issue number: 11

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2018): CiteScore 1.7 SJR 0.203 SNIP 0.61

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Dataflow Process Networks, Multicore, Orcc, RVC-CAL

DOIs:

10.1007/s11265-018-1339-x

Source: Scopus

Source ID: 85041532591

Research output: Contribution to journal > Article > Scientific > peer-review

### **Skew-t Filter and Smoother with Improved Covariance Matrix Approximation**

Filtering and smoothing algorithms for linear discrete-time state-space models with skew-t-distributed measurement noise are proposed. The algorithms use a variational Bayes based posterior approximation with coupled location and skewness variables to reduce the error caused by the variational approximation. Although the variational update is done suboptimally using an expectation propagation algorithm, our simulations show that the proposed method gives a more accurate approximation of the posterior covariance matrix than an earlier proposed variational algorithm. Consequently, the novel filter and smoother outperform the earlier proposed robust filter and smoother and other existing low-complexity alternatives in accuracy and speed. We present both simulations and tests based on real-world navigation data, in particular GPS data in an urban area, to demonstrate the performance of the novel methods. Moreover, the extension of the proposed algorithms to cover the case where the distribution of the measurement noise is multivariate skew-t is outlined. Finally, the paper presents a study of theoretical performance bounds for the proposed algorithms.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Automation and Hydraulic Engineering, Linköping University, Linköping University

Contributors: Nurminen, H., Ardeshiri, T., Piche, R., Gustafsson, F.

Pages: 5618-5633  
Publication date: Nov 2018  
Peer-reviewed: Yes  
Early online date: 13 Aug 2018

#### Publication information

Journal: IEEE Transactions on Signal Processing

Volume: 66

Issue number: 21

ISSN (Print): 1053-587X

Ratings:

Scopus rating (2018): CiteScore 9.8 SJR 1.477 SNIP 2.632

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Approximation algorithms, Biological system modeling, Covariance matrices, Cramer-Rao lower bound, expectation propagation, Gaussian distribution, Kalman filter, Noise measurement, robust filtering, RTS smoother, Signal processing algorithms, skew t, Smoothing methods, t-distribution, truncated normal distribution, variational Bayes

Electronic versions:

TSP2018\_postprint

DOIs:

10.1109/TSP.2018.2865434

URLs:

<http://urn.fi/URN:NBN:fi:ty-201809172317>

Source: Scopus

Source ID: 85051630249

Research output: Contribution to journal > Article > Scientific > peer-review

#### Deep Learning Case Study for Automatic Bird Identification

An automatic bird identification system is required for offshore wind farms in Finland. Indubitably, a radar is the obvious choice to detect flying birds, but external information is required for actual identification. We applied visual camera images as external data. The proposed system for automatic bird identification consists of a radar, a motorized video head and a single-lens reflex camera with a telephoto lens. A convolutional neural network trained with a deep learning algorithm is applied to the image classification. We also propose a data augmentation method in which images are rotated and converted in accordance with the desired color temperatures. The final identification is based on a fusion of parameters provided by the radar and the predictions of the image classifier. The sensitivity of this proposed system, on a dataset containing 9312 manually taken original images resulting in  $2.44 \times 10^6$  augmented data set, is 0.9463 as an image classifier. The area under receiver operating characteristic curve for two key bird species is 0.9993 (the White-tailed Eagle) and 0.9496 (The Lesser Black-backed Gull), respectively. We proposed a novel system for automatic bird identification as a real world application. We demonstrated that our data augmentation method is suitable for image classification problem and it significantly increases the performance of the classifier.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Research group: Data-analytics and Optimization, Mathematics

Contributors: Niemi, J., Tantt, J.

Number of pages: 15

Publication date: 29 Oct 2018

Peer-reviewed: Yes

#### Publication information

Journal: Applied Sciences (Switzerland)

Volume: 8

Issue number: 11

Article number: 2089

ISSN (Print): 2076-3417

Ratings:

Scopus rating (2018): SJR 0.379 SNIP 1.029

Original language: English

ASJC Scopus subject areas: Artificial Intelligence, Signal Processing, Computer Vision and Pattern Recognition

Keywords: Machine learning, Deep learning, Convolutional neural networks, Classification, data augmentation, intelligent surveillance systems

DOIs:

10.3390/app8112089

### **Benchmark database for fine-grained image classification of benthic macroinvertebrates**

Managing the water quality of freshwaters is a crucial task worldwide. One of the most used methods to biomonitor water quality is to sample benthic macroinvertebrate communities, in particular to examine the presence and proportion of certain species. This paper presents a benchmark database for automatic visual classification methods to evaluate their ability for distinguishing visually similar categories of aquatic macroinvertebrate taxa. We make publicly available a new database, containing 64 types of freshwater macroinvertebrates, ranging in number of images per category from 7 to 577. The database is divided into three datasets, varying in number of categories (64, 29, and 9 categories). Furthermore, in order to accomplish a baseline evaluation performance, we present the classification results of Convolutional Neural Networks (CNNs) that are widely used for deep learning tasks in large databases. Besides CNNs, we experimented with several other well-known classification methods using deep features extracted from the data.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Qatar University, University of Jyväskylä, Finnish Environment Institute

Contributors: Raitoharju, J., Riabchenko, E., Ahmad, I., Iosifidis, A., Gabbouj, M., Kiranyaz, S., Tirronen, V., Ärje, J., Kärkkäinen, S., Meissner, K.

Number of pages: 11

Pages: 73-83

Publication date: 1 Oct 2018

Peer-reviewed: Yes

#### **Publication information**

Journal: Image and Vision Computing

Volume: 78

ISSN (Print): 0262-8856

Ratings:

Scopus rating (2018): CiteScore 4.9 SJR 0.633 SNIP 1.655

Original language: English

ASJC Scopus subject areas: Signal Processing, Computer Vision and Pattern Recognition

Keywords: Benthic macroinvertebrates, Biomonitoring, Convolutional Neural Networks, Deep learning, Fine-grained classification

DOIs:

10.1016/j.imavis.2018.06.005

Source: Scopus

Source ID: 85052861257

Research output: Contribution to journal › Article › Scientific › peer-review

### **Nonlocality-Reinforced Convolutional Neural Networks for Image Denoising**

We introduce a paradigm for nonlocal sparsity reinforced deep convolutional neural network denoising. It is a combination of a local multiscale denoising by a convolutional neural network (CNN) based denoiser and a nonlocal denoising based on a nonlocal filter (NLF), exploiting the mutual similarities between groups of patches. CNN models are leveraged with noise levels that progressively decrease at every iteration of our framework, while their output is regularized by a nonlocal prior implicit within the NLF. Unlike complicated neural networks that embed the nonlocality prior within the layers of the network, our framework is modular, and it uses standard pretrained CNNs together with standard nonlocal filters. An instance of the proposed framework, called NN3D, is evaluated over large grayscale image datasets showing state-of-the-art performance.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Noiseless Imaging Ltd

Contributors: Cruz, C., Foi, A., Katkovnik, V., Egiuzarian, K.

Number of pages: 5

Pages: 1216-1220

Publication date: 1 Aug 2018

Peer-reviewed: Yes

#### **Publication information**

Journal: IEEE Signal Processing Letters

Volume: 25

Issue number: 8



ISSN (Print): 1070-9908

Ratings:

Scopus rating (2018): CiteScore 7 SJR 0.785 SNIP 1.983

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering, Applied Mathematics

Keywords: BM3D, convolutional neural network, image denoising, nonlocal filters

Electronic versions:

Nonlocality-Reinforced Convolutional Neural Networks 2018

DOIs:

10.1109/LSP.2018.2850222

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002242327>

Source: Scopus

Source ID: 85049097929

Research output: Contribution to journal › Article › Scientific › peer-review

### **Summarization of User-Generated Sports Video by Using Deep Action Recognition Features**

Automatically generating a summary of sports video poses the challenge of detecting interesting moments, or highlights, of a game. Traditional sports video summarization methods leverage editing conventions of broadcast sports video that facilitate the extraction of high-level semantics. However, user-generated videos are not edited, and thus traditional methods are not suitable to generate a summary. In order to solve this problem, this work proposes a novel video summarization method that uses players' actions as a cue to determine the highlights of the original video. A deep neural network-based approach is used to extract two types of action-related features and to classify video segments into interesting or uninteresting parts. The proposed method can be applied to any sports in which games consist of a succession of actions. Especially, this work considers the case of Kendo (Japanese fencing) as an example of a sport to evaluate the proposed method. The method is trained using Kendo videos with ground truth labels that indicate the video highlights. The labels are provided by annotators possessing different experience with respect to Kendo to demonstrate how the proposed method adapts to different needs. The performance of the proposed method is compared with several combinations of different features, and the results show that it outperforms previous summarization methods.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, University of Tokyo, Osaka University, Graduate School of Information Science, Univ of Oulu

Contributors: Tejero-de-Pablos, A., Nakashima, Y., Sato, T., Yokoya, N., Linna, M., Rahtu, E.

Pages: 2000-2011

Publication date: Aug 2018

Peer-reviewed: Yes

Early online date: 15 Jan 2018

### **Publication information**

Journal: IEEE Transactions on Multimedia

Volume: 20

Issue number: 8

ISSN (Print): 1520-9210

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Scopus rating (2018): CiteScore 9.3 SJR 1.222 SNIP 3.016

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Computer Science Applications, Electrical and Electronic Engineering

Keywords: 3D convolutional neural networks, action recognition, Cameras, deep learning, Feature extraction, Games, Hidden Markov models, long short-term memory, Semantics, Sports video summarization, Three-dimensional displays, user-generated video

DOIs:

10.1109/TMM.2018.2794265

Source: Scopus

Source ID: 85041689127

Research output: Contribution to journal › Article › Scientific › peer-review

### **Stabilization to trajectories for parabolic equations**

Both internal and boundary feedback exponential stabilization to trajectories for semilinear parabolic equations in a given bounded domain are addressed. The values of the controls are linear combinations of a finite number of actuators which are supported in a small region. A condition on the family of actuators is given which guarantees the local stabilizability of

the control system. It is shown that a linearization-based Riccati feedback stabilizing controller can be constructed. The results of numerical simulations are presented and discussed.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Mathematics, Johann Radon Institute for Computational and Applied Mathematics

Contributors: Phan, D., Rodrigues, S. S.

Publication date: 1 Jun 2018

Peer-reviewed: Yes

#### Publication information

Journal: Mathematics of Control, Signals, and Systems

Volume: 30

Issue number: 2

Article number: 11

ISSN (Print): 0932-4194

Ratings:

Scopus rating (2018): CiteScore 1.4 SJR 0.386 SNIP 0.701

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Signal Processing, Control and Optimization, Applied Mathematics

Keywords: Feedback stabilization to trajectories, Semilinear parabolic equations

DOIs:

10.1007/s00498-018-0218-0

Source: Scopus

Source ID: 85050079985

Research output: Contribution to journal › Article › Scientific › peer-review

#### Delay-Accuracy Trade-off in Opportunistic Time-of-Arrival Localization

While designing a positioning network, the localization performance is traditionally the main concern. However, collection of measurements together with channel access methods require a nonzero time, causing a delay experienced by network nodes. This fact is usually neglected in positioning-related literature. In terms of the delay-accuracy trade-off, broadcast schemes have an advantage over unicast, provided nodes can be properly synchronized. In this letter, we analyze the delay-accuracy trade-off, for localization schemes in which the position estimates are obtained based on broadcasted ranging signals. We find that for dense networks, the trade-off is the same for cooperative and noncooperative networks, and cannot exceed a certain threshold value.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing, Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing, Chalmers University of Technology

Contributors: Daniel, O., Wymeersch, H., Nurmi, J.

Pages: 763-767

Publication date: Jun 2018

Peer-reviewed: Yes

Early online date: 14 Apr 2018

#### Publication information

Journal: IEEE Signal Processing Letters

Volume: 25

Issue number: 6

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2018): CiteScore 7 SJR 0.785 SNIP 1.983

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

DOIs:

10.1109/LSP.2018.2826470

Research output: Contribution to journal › Article › Scientific › peer-review

## Digital Predistortion for Hybrid MIMO Transmitters

This article investigates digital predistortion (DPD) linearization of hybrid beamforming large-scale antenna transmitters. We propose a novel DPD processing and learning technique for an antenna sub-array, which utilizes a combined signal of the individual power amplifier (PA) outputs in conjunction with a decorrelation-based learning rule. In effect, the proposed approach results in minimizing the nonlinear distortions in the direction of the intended receiver. This feature is highly desirable, since emissions in other directions are naturally weak due to beamforming. The proposed parameter learning technique requires only a single observation receiver, and therefore supports simple hardware implementation. It is also shown to clearly outperform the current state-of-the-art technique which utilizes only a single PA for learning. Analysis of the feedback network amplitude and phase imbalances reveals that the technique is robust even to high levels of such imbalances. Finally, we also show that the array system out-of-band emissions are well-behaving in all spatial directions, and essentially below those of the corresponding single-antenna transmitter, due to the combined effects of the DPD and beamforming.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Lund University

Contributors: Abdelaziz, M., Anttila, L., Brihuega, A., Tufvesson, F., Valkama, M.

Pages: 445-454

Publication date: Jun 2018

Peer-reviewed: Yes

Early online date: 7 Apr 2018

### Publication information

Journal: IEEE Journal on Selected Topics in Signal Processing

Volume: 12

Issue number: 3

ISSN (Print): 1932-4553

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Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: 5G, digital predistortion, hybrid beamforming, large-array transmitters, out-of-band emissions, power amplifiers

Electronic versions:

Digital Predistortion for Hybrid MIMO Transmitters 2018

DOIs:

10.1109/JSTSP.2018.2824981

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002061905>

Source: Scopus

Source ID: 85045212003

Research output: Contribution to journal › Article › Scientific › peer-review

## Analysis of common rail pressure signal of dual-fuel large industrial engine for identification of injection duration of pilot diesel injectors

In this paper, we address the problem of identification of injection duration of common rail (CR) diesel pilot injectors of dual-fuel engines. In these pilot injectors, the injected volume is small and the repeatability of injections and identification of drifts of injectors are important factors, which need to be taken into account in order to achieve good repeatability (shot-to-shot with every cylinder) and therefore a well-balanced engine and furthermore reduced overall wear. This information can then be used for calibration and diagnostics purposes to guarantee engine longevity facilitated by consistent operating conditions throughout the life of the unit. A diagnostics method based on analysis of CR pressure with experimental results is presented in this paper. Using the developed method, the relative duration of injection events can be identified for multiple injectors. We use the phenomenon of drop in rail pressure due to an injection event as a feature of the injection process. The method is based on filtered CR pressure data during and after the injection event. First, the pressure signal during injection is extracted after control of each injection event. After that, the signal is normalized and filtered. Then a derivative of the filtered signal is calculated. Change in the derivative of the filtered signal larger than a predefined threshold indicates an injection event that can be detected and its relative duration can be identified. We present the experimental results and demonstrate the efficacy of the proposed methods using two different types of pressure sensors. We are able to properly identify a change of  $\geq 10 \mu\text{s}$  (2%, 500  $\mu\text{s}$ ) in injection time. This shows that the developed method detects drifts in injection duration and the magnitude of drift. This information can be used for adaptive control of injection duration, so that finally the injected fuel volume is the same as the original.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed  
Organisations: Automation and Hydraulic Engineering  
Contributors: Krogerus, T., Hyvönen, M., Huhtala, K.  
Pages: 1-9  
Publication date: Mar 2018  
Peer-reviewed: Yes  
Early online date: 6 Dec 2017

#### Publication information

Journal: Fuel  
Volume: 216  
ISSN (Print): 0016-2361  
Ratings:

Scopus rating (2018): CiteScore 8.9 SJR 1.745 SNIP 2.041

Original language: English

ASJC Scopus subject areas: Mechanical Engineering, Signal Processing, Modelling and Simulation, Applied Mathematics

Keywords: Analysis , Dual-fuel engine , Diesel , Common rail , Injector , Rail pressure

Electronic versions:

Accepted author manuscript. Embargo ended: 6/12/19

DOIs:

10.1016/j.fuel.2017.11.152

URLs:

<http://urn.fi/URN:NBN:fi:tty-201712222489>. Embargo ended: 6/12/19

Research output: Contribution to journal > Article > Scientific > peer-review

#### Detection and Classification of Acoustic Scenes and Events: Outcome of the DCASE 2016 Challenge

Public evaluation campaigns and datasets promote active development in target research areas, allowing direct comparison of algorithms. The second edition of the challenge on Detection and Classification of Acoustic Scenes and Events (DCASE 2016) has offered such an opportunity for development of state-of-the-art methods, and succeeded in drawing together a large number of participants from academic and industrial backgrounds. In this paper, we report on the tasks and outcomes of the DCASE 2016 challenge. The challenge comprised four tasks: acoustic scene classification, sound event detection in synthetic audio, sound event detection in real-life audio, and domestic audio tagging. We present in detail each task and analyse the submitted systems in terms of design and performance. We observe the emergence of deep learning as the most popular classification method, replacing the traditional approaches based on Gaussian mixture models and support vector machines. By contrast, feature representations have not changed substantially throughout the years, as mel frequency-based representations predominate in all tasks. The datasets created for and used in DCASE 2016 are publicly available and are a valuable resource for further research.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Research group: Audio research group - ARG, School of Mathematical Sciences, Ecole Centrale de Nantes, IRCCyN UMR CNRS 6597 1, University of Surrey

Contributors: Mesaros, A., Heittola, T., Benetos, E., Foster, P., Lagrange, M., Virtanen, T., Plumbley, M. D.

Pages: 379-393

Publication date: Feb 2018

Peer-reviewed: Yes

Early online date: 28 Nov 2017

#### Publication information

Journal: IEEE/ACM Transactions on Audio Speech and Language Processing

Volume: 26

Issue number: 2

ISSN (Print): 2329-9290

Ratings:

Scopus rating (2018): CiteScore 6.9 SJR 1.045 SNIP 2.428

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Instrumentation, Acoustics and Ultrasonics, Linguistics and Language, Electrical and Electronic Engineering, Speech and Hearing

Keywords: Acoustic scene classification, Acoustics, audio datasets, Event detection, Hidden Markov models, pattern recognition, sound event detection, Speech, Speech processing, Tagging

Electronic versions:

dcase2016\_taslp

DOIs:

10.1109/TASLP.2017.2778423

URLs:

<http://urn.fi/URN:NBN:fi:tty-201802081200>

Source: Scopus

Source ID: 85037645922

Research output: Contribution to journal › Article › Scientific › peer-review

### Probabilistic saliency estimation

In this paper, we model the salient object detection problem under a probabilistic framework encoding the boundary connectivity saliency cue and smoothness constraints into an optimization problem. We show that this problem has a closed form global optimum solution, which estimates the salient object. We further show that along with the probabilistic framework, the proposed method also enjoys a wide range of interpretations, i.e. graph cut, diffusion maps and one-class classification. With an analysis according to these interpretations, we also find that our proposed method provides approximations to the global optimum to another criterion that integrates local/global contrast and large area saliency cues. The proposed unsupervised approach achieves mostly leading performance compared to the state-of-the-art unsupervised algorithms over a large set of salient object detection datasets including around 17k images for several evaluation metrics. Furthermore, the computational complexity of the proposed method is favorable/comparable to many state-of-the-art unsupervised techniques.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Research group: Multimedia Research Group - MRG

Contributors: Aytekin, C., Iosifidis, A., Gabbouj, M.

Number of pages: 14

Pages: 359-372

Publication date: 2018

Peer-reviewed: Yes

Early online date: 20 Sep 2017

### Publication information

Journal: Pattern Recognition

Volume: 74

ISSN (Print): 0031-3203

Ratings:

Scopus rating (2018): CiteScore 10.4 SJR 1.363 SNIP 3.211

Original language: English

ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Artificial Intelligence

Keywords: Diffusion maps, One-class classification, Probabilistic model, Saliency, Salient object detection, Spectral graph cut

DOIs:

[10.1016/j.patcog.2017.09.023](https://doi.org/10.1016/j.patcog.2017.09.023)

Source: Scopus

Source ID: 85032271491

Research output: Contribution to journal › Article › Scientific › peer-review

### Separation of Moving Sound Sources Using Multichannel NMF and Acoustic Tracking

In this paper we propose a method for separation of moving sound sources. The method is based on first tracking the sources and then estimation of source spectrograms using multichannel non-negative matrix factorization (NMF) and extracting the sources from the mixture by single-channel Wiener filtering. We propose a novel multichannel NMF model with time-varying mixing of the sources denoted by spatial covariance matrices (SCM) and provide update equations for optimizing model parameters minimizing squared Frobenius norm. The SCMs of the model are obtained based on estimated directions of arrival of tracked sources at each time frame. The evaluation is based on established objective separation criteria and using real recordings of two and three simultaneous moving sound sources. The compared methods include conventional beamforming and ideal ratio mask separation. The proposed method is shown to exceed the separation quality of other evaluated blind approaches according to all measured quantities. Additionally, we evaluate the method's susceptibility towards tracking errors by comparing the separation quality achieved using annotated ground truth source trajectories.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Research group: Audio research group - ARG

Contributors: Nikunen, J., Diment, A., Virtanen, T.

Pages: 281-295  
Publication date: 2018  
Peer-reviewed: Yes  
Early online date: 16 Nov 2017

#### Publication information

Journal: IEEE/ACM Transactions on Audio Speech and Language Processing

Volume: 26

Issue number: 2

ISSN (Print): 2329-9290

Ratings:

Scopus rating (2018): CiteScore 6.9 SJR 1.045 SNIP 2.428

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Instrumentation, Acoustics and Ultrasonics, Linguistics and Language, Electrical and Electronic Engineering, Speech and Hearing

Keywords: acoustic source tracking, Acoustics, Array signal processing, Direction-of-arrival estimation, Estimation, Mathematical model, microphone arrays, Microphones, moving sound sources, Sound source separation, Spectrogram, time-varying mixing model

DOIs:

10.1109/TASLP.2017.2774925

Source: Scopus

Source ID: 85035748523

Research output: Contribution to journal › Article › Scientific › peer-review

#### Damped Posterior Linearization Filter

In this letter, we propose an iterative Kalman type algorithm based on posterior linearization. The proposed algorithm uses a nested loop structure to optimize the mean of the estimate in the inner loop and update the covariance, which is a computationally more expensive operation, only in the outer loop. The optimization of the mean update is done using a damped algorithm to avoid divergence. Our simulations show that the proposed algorithm is more accurate than existing iterative Kalman filters.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Automation and Hydraulic Engineering, Lab of Electrical and Automation, University of Liverpool

Contributors: Raitoharju, M., Svensson, L., Garcia-Fernandez, A. F., Piche, R.

Publication date: 2018

Peer-reviewed: Yes

Early online date: 13 Feb 2018

#### Publication information

Journal: IEEE Signal Processing Letters

Volume: 25

Issue number: 4

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2018): CiteScore 7 SJR 0.785 SNIP 1.983

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering, Applied Mathematics

Keywords: Bayesian state estimation, Computational modeling, Convergence, Cost function, estimation, Kalman filters, Noise measurement, nonlinear, Signal processing algorithms

Electronic versions:

dampedPLF

DOIs:

10.1109/LSP.2018.2806304

URLs:

<http://urn.fi/URN:NBN:fi:tty-201803281444>

#### Bibliographical note

EXT="Raitoharju, Matti"

Source: Scopus

Source ID: 85042110206

Research output: Contribution to journal › Article › Scientific › peer-review

### **Estimation and Mitigation of Channel Non-Reciprocity in Massive MIMO**

Time-division duplex (TDD) based massive MIMO systems rely on the reciprocity of the wireless propagation channels when calculating the downlink precoders based on uplink pilots. However, the effective uplink and downlink channels incorporating the analog radio front-ends of the base station (BS) and user equipments (UEs) exhibit non-reciprocity due to non-identical behavior of the individual transmit and receive chains. When downlink precoder is not aware of such channel non-reciprocity (NRC), system performance can be significantly degraded due to NRC induced interference terms. In this work, we consider a general TDD-based massive MIMO system where frequency-response mismatches at both the BS and UEs, as well as the mutual coupling mismatch at the BS large-array system all coexist and induce channel NRC. Based on the NRC-impaired signal models, we first propose a novel iterative estimation method for acquiring both the BS and UE side NRC matrices and then also propose a novel NRC-aware downlink precoder design which utilizes the obtained estimates. Furthermore, an efficient pilot signaling scheme between the BS and UEs is introduced in order to facilitate executing the proposed estimation method and the NRC-aware precoding technique in practical systems. Comprehensive numerical results indicate substantially improved spectral efficiency performance when the proposed NRC estimation and NRC-aware precoding methods are adopted, compared to the existing state-of-the-art methods.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Electronics and Communications Engineering, Research group: Wireless Communications and Positioning

Contributors: Raeesi, O., Gokceoglu, A., Valkama, M.

Publication date: 2018

Peer-reviewed: Yes

Early online date: 10 Mar 2018

#### **Publication information**

Journal: IEEE Transactions on Signal Processing

Volume: 66

Issue number: 10

ISSN (Print): 1053-587X

Ratings:

Scopus rating (2018): CiteScore 9.8 SJR 1.477 SNIP 2.632

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Beamforming, channel non-reciprocity, channel state information, frequency-response mismatch, linear precoding, massive MIMO, mutual coupling, time division duplexing (TDD)

Electronic versions:

estimation\_and\_mitigation\_2018

DOIs:

10.1109/TSP.2018.2814992

URLs:

<http://urn.fi/URN:NBN:fi:tuni-201910234054>

Source: Scopus

Source ID: 85043450743

Research output: Contribution to journal > Article > Scientific > peer-review

### **Multi-view predictive latent space learning**

In unsupervised circumstances, multi-view learning seeks a shared latent representation by taking the consensus and complementary principles into account. However, most existing multi-view unsupervised learning approaches do not explicitly lay stress on the predictability of the latent space. In this paper, we propose a novel multi-view predictive latent space learning (MVP) model and apply it to multi-view clustering and unsupervised dimension reduction. The latent space is forced to be predictive by maximizing the correlation between the latent space and feature space of each view. By learning a multi-view graph with adaptive view-weight learning, MVP effectively combines the complementary information from multi-view data. Experimental results on benchmark datasets show that MVP outperforms the state-of-the-art multi-view clustering and unsupervised dimension reduction algorithms.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Tianjin University

Contributors: Yuan, J., Gao, K., Zhu, P., Egiazarian, K.

Publication date: 2018

Peer-reviewed: Yes

Early online date: 2018

### Publication information

Journal: Pattern Recognition Letters

ISSN (Print): 0167-8655

Ratings:

Scopus rating (2018): CiteScore 5.8 SJR 0.662 SNIP 1.729

Original language: English

ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Artificial Intelligence

Keywords: Multi-view learning, Predictive latent space learning, Unsupervised clustering, Unsupervised dimension reduction

DOIs:

10.1016/j.patrec.2018.06.022

Source: Scopus

Source ID: 85049094619

Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### Model-Based Dynamic Scheduling for Multicore Signal Processing

This paper presents a model-based design method and a corresponding new software tool, the HTGS Model-Based Engine (HMBE), for designing and implementing dataflow-based signal processing applications on multi-core architectures. HMBE provides complementary capabilities to HTGS (Hybrid Task Graph Scheduler), a recently-introduced software tool for implementing scalable workflows for high performance computing applications on compute nodes with high core counts and multiple GPUs. HMBE integrates model-based design approaches, founded on dataflow principles, with advanced design optimization techniques provided in HTGS. This integration contributes to (a) making the application of HTGS more systematic and less time consuming, (b) incorporating additional dataflow-based optimization capabilities with HTGS optimizations, and (c) automating significant parts of the HTGS-based design process using a principled approach. In this paper, we present HMBE with an emphasis on the model-based design approaches and the novel dynamic scheduling techniques that are developed as part of the tool. We demonstrate the utility of HMBE via two case studies: an image stitching application for large microscopy images and a background subtraction application for multispectral video streams.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Pervasive Computing, Research area: Computer engineering, University of Maryland, National Institute of Standards and Technology

Contributors: Wu, J., Blattner, T., Keyrouz, W., Bhattacharyya, S. S.

Number of pages: 14

Pages: 1-14

Publication date: 2018

Peer-reviewed: Yes

Early online date: 2018

### Publication information

Journal: Journal of Signal Processing Systems

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2018): CiteScore 1.7 SJR 0.203 SNIP 0.61

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing,

Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Dataflow, Memory management, Multicore platforms, Scheduling

DOIs:

10.1007/s11265-018-1412-5

Source: Scopus

Source ID: 85054798661

Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### Sparse approximations in complex domain based on BM3D modeling

In this paper the concept of sparsity for complex-valued variables is introduced in the following three types: directly in complex domain and for two real-valued pairs phase/amplitude and real/imaginary parts of complex variables. The nonlocal block-matching technique is used for sparsity implementation and filter design for each type of sparsity. These filters are complex domain generalizations of the Block Matching 3D collaborative (BM3D) filter based on the high-order singular value decomposition (HOSVD) in order to generate group-wise adaptive analysis/synthesis transforms. Complex domain denoising is developed and studied as a test-problem for comparison of the designed filters as well as the different



types of sparsity modeling.

#### General information

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Signal Processing, Research group: Computational Imaging-CI  
Contributors: Katkovnik, V., Ponomarenko, M., Egiazarian, K.  
Number of pages: 13  
Pages: 96-108  
Publication date: 1 Dec 2017  
Peer-reviewed: Yes

#### Publication information

Journal: Signal Processing  
Volume: 141  
ISSN (Print): 0165-1684  
Ratings:  
Scopus rating (2017): CiteScore 7.1 SJR 0.94 SNIP 1.974  
Original language: English  
ASJC Scopus subject areas: Control and Systems Engineering, Software, Signal Processing, Computer Vision and Pattern Recognition, Electrical and Electronic Engineering  
Keywords: Block matching, Complex domain, Denoising, Elsevier article, Phase imaging, Sample document, Sparsity  
DOIs:  
10.1016/j.sigpro.2017.05.032  
Source: Scopus  
Source ID: 85020311730  
Research output: Contribution to journal > Article > Scientific > peer-review

#### Multilinear class-specific discriminant analysis

There has been a great effort to transfer linear discriminant techniques that operate on vector data to high-order data, generally referred to as Multilinear Discriminant Analysis (MDA) techniques. Many existing works focus on maximizing the inter-class variances to intra-class variances defined on tensor data representations. However, there has not been any attempt to employ class-specific discrimination criteria for the tensor data. In this paper, we propose a multilinear subspace learning technique suitable for applications requiring class-specific tensor models. The method maximizes the discrimination of each individual class in the feature space while retains the spatial structure of the input. We evaluate the efficiency of the proposed method on two problems, i.e. facial image analysis and stock price prediction based on limit order book data.

#### General information

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Signal Processing, Aarhus Universitet, Laboratory of Signal Processing  
Contributors: Thanh Tran, D., Gabbouj, M., Iosifidis, A.  
Number of pages: 6  
Pages: 131-136  
Publication date: 1 Dec 2017  
Peer-reviewed: Yes

#### Publication information

Journal: Pattern Recognition Letters  
Volume: 100  
ISSN (Print): 0167-8655  
Ratings:  
Scopus rating (2017): CiteScore 5.5 SJR 0.662 SNIP 1.605  
Original language: English  
ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Artificial Intelligence  
Keywords: Class-specific discriminant learning, Face verification, Multilinear discriminant analysis, Stock price prediction  
DOIs:  
10.1016/j.patrec.2017.10.027  
URLs:  
<https://arxiv.org/abs/1710.10695>

#### Bibliographical note

INT=sgn,"Thanh Tran, Dat"  
Source: Scopus

Source ID: 85032300703

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### Big Media Data Analysis

In this editorial a short introduction to the special issue on Big Media Data Analysis is given. The scope of this Editorial is to briefly present methodologies, tasks and applications of big media data analysis and to introduce the papers of the special issue. The special issue includes six papers that span various media analysis application areas like generic image description, medical image and video analysis, distance calculation acceleration and data collection.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Research group: Multimedia Research Group - MRG, Aarhus Universitet, University of Milan Bicocca, Department of Informatics, Aristotle University of Thessaloniki

Contributors: Iosifidis, A., Tefas, A., Pitas, I., Gabbouj, M.

Number of pages: 4

Pages: 105-108

Publication date: 1 Nov 2017

Peer-reviewed: Yes

#### Publication information

Journal: Signal Processing: Image Communication

Volume: 59

ISSN (Print): 0923-5965

Ratings:

Scopus rating (2017): CiteScore 4.6 SJR 0.551 SNIP 1.512

Original language: English

ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Electrical and Electronic Engineering

Keywords: Big Media Data, Data analytics, Deep learning, Machine learning, Statistical learning

DOIs:

10.1016/j.image.2017.10.004

#### Bibliographical note

EXT="Tefas, Anastasios"

Source: Scopus

Source ID: 85033445526

Research output: [Contribution to journal](#) › [Editorial](#) › [Scientific](#) › [peer-review](#)

### Sparse Overcomplete Denoising: Aggregation Versus Global Optimization

Denoising is often addressed via sparse coding with respect to an overcomplete dictionary. There are two main approaches when the dictionary is composed of translates of an orthonormal basis. The first, traditionally employed by techniques such as wavelet cycle spinning, separately seeks sparsity w.r.t. each translate of the orthonormal basis, solving multiple partial optimizations and obtaining a collection of sparse approximations of the noise-free image, which are aggregated together to obtain a final estimate. The second approach, recently employed by convolutional sparse representations, instead seeks sparsity over the entire dictionary via a global optimization. It is tempting to view the former approach as providing a suboptimal solution of the latter. In this letter, we analyze whether global sparsity is a desirable property, and under what conditions the global optimization provides a better solution to the denoising problem. In particular, our experimental analysis shows that the two approaches attain comparable performance in case of natural images and global optimization outperforms the simpler aggregation of partial estimates only when the image admits an extremely sparse representation. We explain this phenomenon by separately studying the bias and variance of these solutions, and by noting that the variance of the global solution increases very rapidly as the original signal becomes less and less sparse.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Politecnico di Milano, Los Alamos National Laboratory

Contributors: Carrera, D., Boracchi, G., Foi, A., Wohlberg, B.

Number of pages: 5

Pages: 1468-1472

Publication date: 1 Oct 2017

Peer-reviewed: Yes

#### Publication information

Journal: IEEE Signal Processing Letters

Volume: 24

Issue number: 10

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2017): CiteScore 6 SJR 0.732 SNIP 1.798

Original language: English

ASJC Scopus subject areas: Signal Processing, Applied Mathematics, Electrical and Electronic Engineering

Keywords: Convolutional sparse coding, denoising, overcomplete representations, sparse representations

Electronic versions:

SPL2017-Carrera-Aggregation\_vs\_Global

DOIs:

10.1109/LSP.2017.2734119

URLs:

<http://urn.fi/URN:NBN:fi:tty-201710051986>

#### **Bibliographical note**

EXT="Carrera, Diego"

EXT="Boracchi, Giacomo"

Source: Scopus

Source ID: 85029186566

Research output: Contribution to journal > Article > Scientific > peer-review

#### **Binary Non-Negative Matrix Deconvolution for Audio Dictionary Learning**

In this study, we propose an unsupervised method for dictionary learning in audio signals. The new method, called binary nonnegative matrix deconvolution (BNMD), is developed and used to discover patterns from magnitude-scale spectrograms. The BNMD models an audio spectrogram as a sum of delayed patterns having binary gains (activations). Only small subsets of patterns can be active for a given spectrogram excerpt. The proposed method was applied to speaker identification and separation tasks. The experimental results show that dictionaries obtained by the BNMD bring much higher speaker identification accuracies averaged over a range of SNRs from -6 dB to 9 dB (91.3%) than the NMD-based dictionaries (37.8-75.4%). The BNMD also gives a benefit over dictionaries obtained using vector quantization (87.8%). For bigger dictionaries the difference between the BNMD and the vector quantization (VQ) is getting smaller. For the speech separation task the BNMD dictionary gave a slight improvement over the VQ.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Research group: Audio research group - ARG, Poznan University of Technology, University of Oldenburg, Yousician Ltd.

Contributors: Drgas, S., Virtanen, T., Lücke, J., Hurmalainen, A.

Number of pages: 13

Pages: 1644-1656

Publication date: 1 Aug 2017

Peer-reviewed: Yes

#### **Publication information**

Journal: IEEE/ACM Transactions on Audio Speech and Language Processing

Volume: 25

Issue number: 8

ISSN (Print): 2329-9290

Ratings:

Scopus rating (2017): CiteScore 4.9 SJR 0.841 SNIP 2.152

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Instrumentation, Acoustics and Ultrasonics, Linguistics and Language, Speech and Hearing, Electrical and Electronic Engineering

Keywords: Sparse coding, speaker recognition, speech separation

Electronic versions:

BNMD

DOIs:

10.1109/TASLP.2017.2709909

URLs:

<http://urn.fi/URN:NBN:fi:tty-201712212459>

#### **Bibliographical note**

EXT="Hurmalaianen, Antti"

Source: Scopus

Source ID: 85028409183

Research output: Contribution to journal › Article › Scientific › peer-review

### **Power Mitigation by Performance Equalization in a Heterogeneous Reconfigurable Multicore Architecture**

This paper presents an integrated self-aware computing model mitigating the power dissipation of a heterogeneous reconfigurable multicore architecture by dynamically scaling the operating frequency of each core. The power mitigation is achieved by equalizing the performance of all the cores for an uninterrupted exchange of data. The multicore platform consists of heterogeneous Coarse-Grained Reconfigurable Arrays (CGRAs) of application-specific sizes and a Reduced Instruction-Set Computing (RISC) core. The CGRAs and the RISC core are integrated with each other over a Network-on-Chip (NoC) of six nodes arranged in a topology of two rows and three columns. The RISC core constantly monitors and controls the performance of each CGRA accelerator by adjusting the operating frequencies unless the performance of all the CGRAs is optimally balanced over the platform. The CGRA cores on the platform are processing some of the most computationally-intensive signal processing algorithms while the RISC core establishes packet based synchronization between the cores for computation and communication. All the cores can access each other's computational and memory resources while processing the kernels simultaneously and independently of each other. Besides general-purpose processing and overall platform supervision, the RISC processor manages performance equalization among all the cores which mitigates the overall dynamic power dissipation by 20.7 % for a proof-of-concept test.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing

Contributors: Hussain, W., Hoffmann, H., Ahonen, T., Nurmi, J.

Number of pages: 11

Pages: 287–297

Publication date: Jun 2017

Peer-reviewed: Yes

Early online date: 5 May 2016

#### **Publication information**

Journal: Journal of Signal Processing Systems

Volume: 87

Issue number: 3

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2017): CiteScore 1.7 SJR 0.216 SNIP 0.632

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Modelling and Simulation, Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science

Keywords: CGRA, Dark silicon, Heterogeneous, Multicore, Power dissipation, Reconfigurable

DOIs:

10.1007/s11265-016-1142-5

Source: Scopus

Source ID: 84965022070

Research output: Contribution to journal › Article › Scientific › peer-review

### **Sparse phase imaging based on complex domain nonlocal BM3D techniques**

The paper is addressed to 2D phase and amplitude estimation of complex-valued signals – that is, in particular, to estimation of modulo- $2\pi$  interferometric phase images from periodic and noisy observations. These degradation mechanisms make phase image estimation a challenging problem. A sparse nonlocal data-adaptive imaging formalized in complex domain is used for phase and amplitude image reconstruction. Following the procedure of patch-based technique, the image is partitioned into small overlapping square patches. Block Matching Three Dimensional (BM3D) technique is developed for forming complex domain sparse spectral representations of complex-valued data. High Order Singular Value Decomposition (HOSVD) applied to BM3D groups enables the design of the orthonormal complex domain 3D transforms which are data adaptive and different for each BM3Ds group. An iterative version of the complex domain BM3D is designed from variational formulation of the problem. The convergence of this algorithm is shown. The effectiveness of the new sparse coding based algorithms is illustrated in simulation experiments where they demonstrate the state-of-the-art performance.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed  
Organisations: Signal Processing, Research group: Computational Imaging-CI  
Contributors: Katkovnik, V., Egiazarian, K.  
Number of pages: 14  
Pages: 72-85  
Publication date: 1 Apr 2017  
Peer-reviewed: Yes

#### **Publication information**

Journal: Digital Signal Processing  
Volume: 63  
ISSN (Print): 1051-2004  
Ratings:

Scopus rating (2017): CiteScore 4.5 SJR 0.55 SNIP 1.397

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Complex domain image denoising, Complex domain sparsity, HOSVD, Non-local block matching, Phase imaging

DOIs:

10.1016/j.dsp.2017.01.002

Source: Scopus

Source ID: 85009165629

Research output: Contribution to journal › Article › Scientific › peer-review

#### **Neighborhood Matching for Image Retrieval**

In the last few years, large-scale image retrieval has attracted a lot of attention from the multimedia community. Usual approaches addressing this task first generate an initial ranking of the reference images using fast approximations that do not take into consideration the spatial arrangement of local features in the image (e.g., the bag-of-words paradigm). The top positions of the rankings are then re-estimated with verification methods that deal with more complex information, such as the geometric layout of the image. This verification step allows pruning of many false positives at the expense of an increase in the computational complexity, which may prevent its application to large-scale retrieval problems. This paper describes a geometric method known as neighborhood matching (NM), which revisits the keypoint matching process by considering a neighborhood around each keypoint and improves the efficiency of a geometric verification step in the image search system. Multiple strategies are proposed and compared to incorporate NM into a large-scale image retrieval framework. A detailed analysis and comparison of these strategies and baseline methods have been investigated. The experiments show that the proposed method not only improves the computational efficiency, but also increases the retrieval performance and outperforms state-of-the-art methods in standard datasets, such as the Oxford 5 k and 105 k datasets, for which the spatial verification step has a significant impact on the system performance.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, Universidad Carlos III de Madrid, Purdue University

Contributors: González-Díaz, I., Birinci, M., Díaz-De-María, F., Delp, E. J.

Number of pages: 15

Pages: 544-558

Publication date: 1 Mar 2017

Peer-reviewed: Yes

#### **Publication information**

Journal: IEEE Transactions on Multimedia

Volume: 19

Issue number: 3

ISSN (Print): 1520-9210

Ratings:

Scopus rating (2017): CiteScore 7.8 SJR 0.954 SNIP 2.302

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Computer Science Applications, Electrical and Electronic Engineering

Keywords: Geometric verification, image retrieval, neighborhood matching (NM), robust estimation

DOIs:

10.1109/TMM.2016.2616298

Source: Scopus

Source ID: 85013466531

Research output: Contribution to journal › Article › Scientific › peer-review

### **State Estimation for a Class of Piecewise Affine State-Space Models**

We propose a filter for piecewise affine state-space models. In each filtering recursion, the true filtering posterior distribution is a mixture of truncated normal distributions. The proposed filter approximates the mixture with a single normal distribution via moment matching. The proposed algorithm is compared with the extended Kalman filter (EKF) in a numerical simulation, where the proposed method obtains, on average, better root mean square error than the EKF.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Automation Science and Engineering, Research area: Dynamic Systems, Research group: Positioning, Universidade Federal do Rio Grande do Sul, Porto Alegre, Linköping University

Contributors: Rui, R., Ardeshiri, T., Nurminen, H., Bazanella, A., Gustafsson, F.

Number of pages: 5

Pages: 61-65

Publication date: Jan 2017

Peer-reviewed: Yes

Early online date: 1 Dec 2016

#### **Publication information**

Journal: IEEE Signal Processing Letters

Volume: 24

Issue number: 1

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2017): CiteScore 6 SJR 0.732 SNIP 1.798

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics

Keywords: piecewise affine, state-space models, nonlinear filtering, Kalman filtering

DOIs:

10.1109/LSP.2016.2633624

URLs:

<https://arxiv.org/abs/1609.00365>

Research output: Contribution to journal > Article > Scientific > peer-review

### **Data Flow Algorithms for Processors with Vector Extensions: Handling Actors With Internal State**

Full use of the parallel computation capabilities of present and expected CPUs and GPUs requires use of vector extensions. Yet many actors in data flow systems for digital signal processing have internal state (or, equivalently, an edge that loops from the actor back to itself) that impose serial dependencies between actor invocations that make vectorizing across actor invocations impossible. Ideally, issues of inter-thread coordination required by serial data dependencies should be handled by code written by parallel programming experts that is separate from code specifying signal processing operations. The purpose of this paper is to present one approach for so doing in the case of actors that maintain state. We propose a methodology for using the parallel scan (also known as prefix sum) pattern to create algorithms for multiple simultaneous invocations of such an actor that results in vectorizable code. Two examples of applying this methodology are given: (1) infinite impulse response filters and (2) finite state machines. The correctness and performance of the resulting IIR filters and one class of FSMs are studied.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Pervasive Computing, Research area: Computer engineering, Signal Processing Research Community (SPRC), Keysight Technologies, University of Maryland

Contributors: Barford, L., Bhattacharyya, S. S., Liu, Y.

Pages: 21-31

Publication date: 2017

Peer-reviewed: Yes

#### **Publication information**

Journal: Journal of Signal Processing Systems

Volume: 87

Issue number: 1

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2017): CiteScore 1.7 SJR 0.216 SNIP 0.632

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Modelling and Simulation, Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science

Keywords: Data flow computing, Digital signal processing, Graphics processing units, Parallel algorithms, Vector processors

DOIs:

10.1007/s11265-015-1045-x

Source: Scopus

Source ID: 84946115179

Research output: Contribution to journal › Article › Scientific › peer-review

### **On the existence of the solution for one-dimensional discrete phase retrieval problem**

We consider the discrete form of the one-dimensional phase retrieval (1-D DPhR) problem from the point of view of input magnitude data. The direct method can provide a solution to the 1-D DPhR problem if certain conditions are satisfied by the input magnitude data, namely the corresponding trigonometric polynomial must be nonnegative. To test positivity of a trigonometric polynomial a novel DFT-based criterion is proposed. We use this DFT criterion for different sets of input magnitude data to evaluate whether the direct method applied to the 1-D DPhR problem leads to a solution in all explored cases.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Technical University of Cluj-Napoca Universitatea Tehnica din Cluj-Napoca, Tampere International Center for Signal Processing

Contributors: Rusu, C., Astola, J.

Number of pages: 8

Pages: 195–202

Publication date: 2017

Peer-reviewed: Yes

#### **Publication information**

Journal: Signal, Image and Video Processing

Volume: 11

Issue number: 2

ISSN (Print): 1863-1703

Ratings:

Scopus rating (2017): CiteScore 3 SJR 0.485 SNIP 1.228

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing

Keywords: Discrete Fourier transform, Phase retrieval, Positive trigonometric polynomials, Signal reconstruction

DOIs:

10.1007/s11760-016-0919-0

#### **Bibliographical note**

EXT="Rusu, Corneliu"

Source: Scopus

Source ID: 84976319640

Research output: Contribution to journal › Article › Scientific › peer-review

### **Parallel Digital Predistortion Design on Mobile GPU and Embedded Multicore CPU for Mobile Transmitters**

Digital predistortion (DPD) is a widely adopted baseband processing technique in current radio transmitters. While DPD can effectively suppress unwanted spurious spectrum emissions stemming from imperfections of analog RF and baseband electronics, it also introduces extra processing complexity and poses challenges on efficient and flexible implementations, especially for mobile cellular transmitters, considering their limited computing power compared to basestations. In this paper, we present high data rate implementations of broadband DPD on modern embedded processors, such as mobile GPU and multicore CPU, by taking advantage of emerging parallel computing techniques for exploiting their computing resources. We further verify the suppression effect of DPD experimentally on real radio hardware platforms. Performance evaluation results of our DPD design demonstrate the high efficacy of modern general purpose mobile processors on accelerating DPD processing for a mobile transmitter.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Rice University, Univ of Oulu

Contributors: Li, K., Ghazi, A., Tarver, C., Boutellier, J., Abdelaziz, M., Anttila, L., Juntti, M., Valkama, M., Cavallaro, J. R.  
Number of pages: 14  
Pages: 417–430  
Publication date: 2017  
Peer-reviewed: Yes

#### Publication information

Journal: Journal of Signal Processing Systems

Volume: 89

Issue number: 3

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2017): CiteScore 1.7 SJR 0.216 SNIP 0.632

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: CUDA, Digital predistortion, Mobile SoC, NEON SIMD, Software-defined radio

Electronic versions:

Parallel Digital Predistortion Design on Mobile GPU 2017

DOIs:

10.1007/s11265-017-1233-y

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002041822>

Source: Scopus

Source ID: 85013872658

Research output: Contribution to journal > Article > Scientific > peer-review

#### Implementation of a Multirate Resampler for Multi-carrier Systems on GPUs

Efficient sample rate conversion is of widespread importance in modern communication and signal processing systems. Although many efficient kinds of polyphase filterbank structures exist for this purpose, they are mainly geared toward serial, custom, dedicated hardware implementation for a single task. There is, therefore, a need for more flexible sample rate conversion systems that are resource-efficient, and provide high performance. To address these challenges, we present in this paper an all-software-based, fully parallel, multirate resampling method based on graphics processing units (GPUs). The proposed approach is well-suited for wireless communication systems that have simultaneous requirements on high throughput and low latency. Utilizing the multidimensional architecture of GPUs, our design allows efficient parallel processing across multiple channels and frequency bands at baseband. The resulting architecture provides flexible sample rate conversion that is designed to address modern communication requirements, including real-time processing of multiple carriers simultaneously.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Pervasive Computing, University of Maryland

Contributors: Kim, S. C., Bhattacharyya, S. S.

Number of pages: 11

Pages: 445–455

Publication date: 2017

Peer-reviewed: Yes

Early online date: 30 Mar 2017

#### Publication information

Journal: Journal of Signal Processing Systems

Volume: 89

Issue number: 3

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2017): CiteScore 1.7 SJR 0.216 SNIP 0.632

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Carrier aggregation, GPU-based radio, Multirate signal processing, Polyphase decimator, Polyphase interpolator, Polyphase resampler

DOIs:

10.1007/s11265-017-1239-5



Source: Scopus

Source ID: 85016560476

Research output: Contribution to journal › Article › Scientific › peer-review

### **Design Flow for GPU and Multicore Execution of Dynamic Dataflow Programs**

Dataflow programming has received increasing attention in the age of multicore and heterogeneous computing. Modular and concurrent dataflow program descriptions enable highly automated approaches for design space exploration, optimization and deployment of applications. A great advance in dataflow programming has been the recent introduction of the RVC-CAL language. Having been standardized by the ISO, the RVC-CAL dataflow language provides a solid basis for the development of tools, design methodologies and design flows. This paper proposes a novel design flow for mapping RVC-CAL dataflow programs to parallel and heterogeneous execution platforms. Through the proposed design flow the programmer can describe an application in the RVC-CAL language and map it to multi- and many-core platforms, as well as GPUs, for efficient execution. The functionality and efficiency of the proposed approach is demonstrated by a parallel implementation of a video processing application and a run-time reconfigurable filter for telecommunications. Experiments are performed on GPU and multicore platforms with up to 16 cores, and the results show that for high-performance applications the proposed design flow provides up to  $4 \times$  higher throughput than the state-of-the-art approach in multicore execution of RVC-CAL programs.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Pervasive Computing, Research area: Computer engineering, Center for Machine Vision and Signal Analysis, Univ of Oulu

Contributors: Boutellier, J., Nyländén, T.

Number of pages: 10

Pages: 469–478

Publication date: 2017

Peer-reviewed: Yes

#### **Publication information**

Journal: Journal of Signal Processing Systems

Volume: 89

Issue number: 3

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2017): CiteScore 1.7 SJR 0.216 SNIP 0.632

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Dataflow computing, Design automation, Parallel processing, Signal processing

DOIs:

10.1007/s11265-017-1260-8

Source: Scopus

Source ID: 85021239311

Research output: Contribution to journal › Article › Scientific › peer-review

### **A Hybrid Task Graph Scheduler for High Performance Image Processing Workflows**

Designing applications for scalability is key to improving their performance in hybrid and cluster computing. Scheduling code to utilize parallelism is difficult, particularly when dealing with data dependencies, memory management, data motion, and processor occupancy. The Hybrid Task Graph Scheduler (HTGS) improves programmer productivity when implementing hybrid workflows for multi-core and multi-GPU systems. The Hybrid Task Graph Scheduler (HTGS) is an abstract execution model, framework, and API that increases programmer productivity when implementing hybrid workflows for such systems. HTGS manages dependencies between tasks, represents CPU and GPU memories independently, overlaps computations with disk I/O and memory transfers, keeps multiple GPUs occupied, and uses all available compute resources. Through these abstractions, data motion and memory are explicit; this makes data locality decisions more accessible. To demonstrate the HTGS application program interface (API), we present implementations of two example algorithms: (1) a matrix multiplication that shows how easily task graphs can be used; and (2) a hybrid implementation of microscopy image stitching that reduces code size by  $\approx 43\%$  compared to a manually coded hybrid workflow implementation and showcases the minimal overhead of task graphs in HTGS. Both of the HTGS-based implementations show good performance. In image stitching the HTGS implementation achieves similar performance to the hybrid workflow implementation. Matrix multiplication with HTGS achieves 1.3x and 1.8x speedup over the multi-threaded OpenBLAS library for  $16k \times 16k$  and  $32k \times 32k$  size matrices, respectively.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Pervasive Computing, Research area: Computer engineering, University of Maryland Baltimore County, National Institute of Standards and Technology, Department of Electrical and Computer Engineering, University of Maryland

Contributors: Blattner, T., Keyrouz, W., Bhattacharyya, S. S., Halem, M., Brady, M.

Number of pages: 11

Pages: 457–467

Publication date: 2017

Peer-reviewed: Yes

### Publication information

Journal: Journal of Signal Processing Systems

Volume: 89

Issue number: 3

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2017): CiteScore 1.7 SJR 0.216 SNIP 0.632

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Dataflow, Heterogeneous architectures, Hybrid workflows, Image processing, Matrix multiplication, Task graph  
DOIs:

10.1007/s11265-017-1262-6

Source: Scopus

Source ID: 85025108758

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### Minimum description length sparse modeling and region merging for lossless plenoptic image compression

This paper proposes a complete lossless compression method for exploiting the redundancy of rectified light-field data. The light-field data consists of an array of rectified subaperture images, called for short views, which are segmented into regions according to an optimized partition of the central view. Each region of a view is predictively encoded using a specifically designed sparse predictor, exploiting the smoothness of each color component in the current view, and the cross-similarities with the other color components and already encoded neighbor views. The views are encoded sequentially, using a spiral scanning order, each view being predicted based on several similar neighbor views. The essential challenge for each predictor becomes choosing the most relevant regressors, from a large number of possible regressors belonging to the neighbor views. The proposed solution here is to couple sparse predictor design and minimum description length (MDL) principle, where the data description length is measured by an implementable code length, optimized for a class of probability models. The paper introduces a region merging segmentation under MDL criterion for partitioning the views into regions having their own specific sparse predictors. In experiments, several fast sparse design methods are considered. The proposed scheme is evaluated over a database of plenoptic images, achieving better lossless compression ratios than straightforward usage of standard image and video compression methods for the spiral sequence of views.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing, University of California San Diego

Contributors: Helin, P., Astola, P., Rao, B., Tabus, I.

Publication date: 2017

Peer-reviewed: Yes

### Publication information

Journal: IEEE Journal on Selected Topics in Signal Processing

Volume: 11

Issue number: 7

ISSN (Print): 1932-4553

Ratings:

Scopus rating (2017): CiteScore 11.9 SJR 1.331 SNIP 3.054

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Cameras, Data structures, Encoding, Image coding, Image color analysis, Image segmentation, light-field coding, lossless compression, minimum description length segmentation, plenoptics, sparse prediction, Spirals

DOIs:

10.1109/JSTSP.2017.2737967

Source: Scopus

Source ID: 85028989947

Research output: Contribution to journal › Article › Scientific › peer-review

### **Data Rate Assessment on L2–L3 CPU Bus and Bus between CPU and RAM in Modern CPUs**

In this paper, modern CPU architecture with several different cache levels is described and current CPU performance limitations such as frequency increase bounds are discussed. As changes to the currently existing architecture are usually proposed as a way of increasing CPU performance, data rates of the internal and external CPU interfaces must be known. This information would help to assess the applicability of proposed solutions and to optimize them. This paper is aimed at obtaining real values of traffic on an L2–L3 cache interface inside a CPU and a CPU–RAM bus load, as well as showing the dependences of the total traffic on the studied interfaces on the number of active cores, CPU frequency, and test type. A measurement methodology using an Intel Performance Counter Monitor is provided and the equations used to obtain data rates from the internal CPU counters are explained. Both real-life and synthetic tests are described. The dependence of total traffic on the number of active cores and the dependence of total traffic on CPU frequency are provided as plots. The dependence of total traffic on test type is provided as a bar plot for multiple CPU frequencies.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Electronics and Communications Engineering, Yaroslavl State University

Contributors: Komar, M. S.

Number of pages: 8

Pages: 701-708

Publication date: 2017

Peer-reviewed: Yes

#### **Publication information**

Journal: Automatic Control and Computer Sciences

Volume: 51

Issue number: 7

ISSN (Print): 0146-4116

Ratings:

Scopus rating (2017): CiteScore 0.6 SJR 0.218 SNIP 0.613

Original language: English

ASJC Scopus subject areas: Software, Control and Systems Engineering, Signal Processing

Keywords: data rate assessment, multicore CPUs, Network-on-Chip, NoC, System-on-Chip, Wireless Network- on-Chip, WNoC

DOIs:

10.3103/S014641161707029X

#### **Bibliographical note**

INT=elt,"Komar, M. S."

Source: Scopus

Source ID: 85042229432

Research output: Contribution to journal › Article › Scientific › peer-review

### **Adaptive tracking of people and vehicles using mobile platforms**

Tracking algorithms have important applications in detection of humans and vehicles for border security and other areas. For large-scale deployment of such algorithms, it is critical to provide methods for their cost- and energy-efficient realization. To this end, commodity mobile devices have significant potential for use as prototyping and testing platforms due to their low cost, widespread availability, and integration of advanced communications, sensing, and processing features. Prototypes developed on mobile platforms can be tested, fine-tuned, and demonstrated in the field and then provide reference implementations for application-specific disposable sensor node implementations that are targeted for deployment. In this paper, we develop a novel, adaptive tracking system that is optimized for energy-efficient, real-time operation on off-the-shelf mobile platforms. Our tracking system applies principles of dynamic data-driven application systems (DDDAS) to periodically monitor system operating characteristics and apply these measurements to dynamically adapt the specific classifier configurations that the system employs. Our resulting adaptive approach enables powerful optimization of trade-offs among energy consumption, real-time performance, and tracking accuracy based on time-varying changes in operational characteristics. Through experiments employing an Android-based tablet platform, we demonstrate the efficiency of our proposed tracking system design for multimode detection of human and vehicle targets.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Pervasive Computing, Research area: Computer engineering, University of Maryland, U.S. Army Research Laboratory, Technische Universitat Munchen  
Contributors: Ben Salem, H., Damarla, T., Sudusinghe, K., Stechele, W., Bhattacharyya, S. S.  
Publication date: 1 Dec 2016  
Peer-reviewed: Yes

#### Publication information

Journal: Eurasip Journal on Advances in Signal Processing  
Volume: 2016  
Issue number: 1  
Article number: 65  
ISSN (Print): 1687-6172  
Ratings:

Scopus rating (2016): CiteScore 2.5 SJR 0.345 SNIP 1.088

Original language: English

ASJC Scopus subject areas: Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: Acoustic sensors, Dataflow graphs, DDDAS, Mobile platforms, Signal processing systems, Target tracking

Electronic versions:

Adaptive tracking of people and vehicles using mobile platforms

DOIs:

10.1186/s13634-016-0356-9

URLs:

<http://urn.fi/URN:NBN:fi:ty-201606284314>

Source: Scopus

Source ID: 84971500315

Research output: Contribution to journal > Article > Scientific > peer-review

#### Generalized Hampel Filters

The standard median filter based on a symmetric moving window has only one tuning parameter: the window width. Despite this limitation, this filter has proven extremely useful and has motivated a number of extensions: weighted median filters, recursive median filters, and various cascade structures. The Hampel filter is a member of the class of decision filters that replaces the central value in the data window with the median if it lies far enough from the median to be deemed an outlier. This filter depends on both the window width and an additional tuning parameter  $t$ , reducing to the median filter when  $t=0$ , so it may be regarded as another median filter extension. This paper adopts this view, defining and exploring the class of generalized Hampel filters obtained by applying the median filter extensions listed above: weighted Hampel filters, recursive Hampel filters, and their cascades. An important concept introduced here is that of an implosion sequence, a signal for which generalized Hampel filter performance is independent of the threshold parameter  $t$ . These sequences are important because the added flexibility of the generalized Hampel filters offers no practical advantage for implosion sequences. Partial characterization results are presented for these sequences, as are useful relationships between root sequences for generalized Hampel filters and their median-based counterparts. To illustrate the performance of this filter class, two examples are considered: one is simulation-based, providing a basis for quantitative evaluation of signal recovery performance as a function of  $t$ , while the other is a sequence of monthly Italian industrial production index values that exhibits glaring outliers.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Video, DataRobot, Aalto University

Contributors: Pearson, R. K., Neuvo, Y., Astola, J., Gabbouj, M.

Publication date: 1 Dec 2016

Peer-reviewed: Yes

#### Publication information

Journal: Eurasip Journal on Advances in Signal Processing  
Volume: 2016  
Issue number: 1  
Article number: 87  
ISSN (Print): 1687-6172  
Ratings:

Scopus rating (2016): CiteScore 2.5 SJR 0.345 SNIP 1.088

Original language: English

ASJC Scopus subject areas: Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Electronic versions:

Generalized Hampel Filters

DOIs:

10.1186/s13634-016-0383-6

URLs:

<http://urn.fi/URN:NBN:fi:tyy-201608254463>

Source: Scopus

Source ID: 84981165367

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### **Blind Separation of Audio Mixtures Through Nonnegative Tensor Factorization of Modulation Spectrograms**

This paper presents an algorithm for unsupervised single-channel source separation of audio mixtures. The approach specifically addresses the challenging case of separation where no training data are available. By representing mixtures in the modulation spectrogram (MS) domain, we exploit underlying similarities in patterns present across frequency. A three-dimensional tensor factorization is able to take advantage of these redundant patterns, and is used to separate a mixture into an approximated sum of components by minimizing a divergence cost. Furthermore, we show that the basic tensor factorization can be extended with convolution in time being used to improve separation results and provide update rules to learn components in such a manner. Following factorization, sources are reconstructed in the audio domain from estimated components using a novel approach based on reconstruction masks that are learned using MS activations, and then applied to a mixture spectrogram. We demonstrate that the proposed method produces superior separation performance to a spectrally based nonnegative matrix factorization approach, in terms of source-to-distortion ratio. We also compare separation with the perceptually motivated interference-related perceptual score metric and identify cases with higher performance.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Audio research group

Contributors: Barker, T., Virtanen, T.

Number of pages: 13

Pages: 2377-2389

Publication date: 1 Dec 2016

Peer-reviewed: Yes

#### **Publication information**

Journal: *Ieee-Acm transactions on audio speech and language processing*

Volume: 24

Issue number: 12

ISSN (Print): 2329-9290

Ratings:

Scopus rating (2016): CiteScore 2.7 SJR 0.711 SNIP 3.007

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Instrumentation, Acoustics and Ultrasonics, Linguistics and Language, Speech and Hearing, Electrical and Electronic Engineering

Keywords: Factorization, nonnegative matrix factorization (NMF), source separation, speech enhancement

DOIs:

10.1109/TASLP.2016.2602546

Source: Scopus

Source ID: 84991442139

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### **Ensembles of dense and dense sampling descriptors for the HEP-2 cells classification problem**

The classification of Human Epithelial (HEp-2) cells images, acquired through Indirect Immunofluorescence (IIF) microscopy, is an effective method to identify staining patterns in patient sera. Indeed it can be used for diagnostic purposes, in order to reveal autoimmune diseases. However, the automated classification of IIF HEp-2 cell patterns represents a challenging task, due to the large intra-class and the small inter-class variability. Consequently, recent HEp-2 cell classification contests have greatly spurred the development of new IIF image classification systems. Here we propose an approach for the automatic classification of IIF HEp-2 cell images by fusion of several texture descriptors by ensemble of support vector machines combined by sum rule. Its effectiveness is evaluated using the HEp-2 cells dataset used for the "Performance Evaluation of Indirect Immunofluorescence Image Analysis Systems" contest, hosted by the International Conference on Pattern Recognition in 2014: the accuracy on the testing set is 79.85%. The same dataset was used to test an ensemble of ternary-encoded local phase quantization descriptors, built by perturbation approaches: the accuracy on the training set is 84.16%. Finally, this ensemble was validated on 14 additional datasets, obtaining the best performance on 11 datasets. Our MATLAB code is available at <https://www.dei.unipd.it/node/2357>.

#### **General information**

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Department of Electronics and Communications Engineering, Research group: Computational Biophysics and Imaging Group, BioMediTech, Integrated Technologies for Tissue Engineering Research (ITTE), Università degli Studi di Padova, Italy, University of Bologna  
Contributors: Nanni, L., Lumini, A., dos Santos, F. L. C., Paci, M., Hyttinen, J.  
Pages: 28-35  
Publication date: 15 Oct 2016  
Peer-reviewed: Yes

#### Publication information

Journal: Pattern Recognition Letters  
Volume: 82  
ISSN (Print): 0167-8655  
Ratings:  
Scopus rating (2016): CiteScore 5.2 SJR 0.729 SNIP 1.678  
Original language: English  
ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing  
Keywords: Bag-of-features, Ensemble, HEp-2 cell classification, Machine learning, Support vector machine, Texture descriptors  
Electronic versions:  
Ensembles of dense and dense sampling descriptors for the HEp -2 cells classification problem. Embargo ended: 15/10/18  
DOIs:  
10.1016/j.patrec.2016.01.026  
URLs:  
<http://urn.fi/URN:NBN:fi:ty-201611294825>. Embargo ended: 15/10/18  
Source: Scopus  
Source ID: 84961195136  
Research output: Contribution to journal › Article › Scientific › peer-review

#### Image interpolation based on non-local geometric similarities and directional gradients

Image interpolation offers an efficient way to compose a high-resolution (HR) image from the observed low-resolution (LR) image. Advanced interpolation techniques design the interpolation weighting coefficients by solving a minimum mean-square-error (MMSE) problem in which the local geometric similarity is often considered. However, using local geometric similarities cannot usually make the MMSE-based interpolation as reliable as expected. To solve this problem, we propose a robust interpolation scheme by using the nonlocal geometric similarities to construct the HR image. In our proposed method, the MMSE-based interpolation weighting coefficients are generated by solving a regularized least squares problem that is built upon a number of dual-reference patches drawn from the given LR image and regularized by the directional gradients of these patches. Experimental results demonstrate that our proposed method offers a remarkable quality improvement as compared to some state-of-the-art methods, both objectively and subjectively.

#### General information

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Department of Signal Processing, Research group: Video, University of Electronic Science and Technology of China  
Contributors: Zhu, S., Zeng, B., Zeng, L., Gabbouj, M.  
Number of pages: 13  
Pages: 1707-1719  
Publication date: 1 Sep 2016  
Peer-reviewed: Yes

#### Publication information

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Volume: 18  
Issue number: 9  
ISSN (Print): 1520-9210  
Ratings:  
Scopus rating (2016): CiteScore 8.1 SJR 1.298 SNIP 2.536  
Original language: English  
ASJC Scopus subject areas: Signal Processing, Media Technology, Computer Science Applications, Electrical and Electronic Engineering  
Keywords: Directional gradient, geometric similarity, image interpolation, minimum mean square error (MMSE)

DOIs:

10.1109/TMM.2016.2593039

Source: Scopus

Source ID: 84983409176

Research output: Contribution to journal › Article › Scientific › peer-review

### **A software tool for studying the size and shape of human cardiomyocytes**

**Background and objectives** Due to development of imaging systems the amount of digital images obtained in the biological field has been growing in recent years. These images contain information that is not directly measurable, e.g. the area covered by a single cell. In most of the current imaging programs the regions of interest (ROI), e.g. individual cells, need to be manually outlined. Automation of processing and analyzing the images would ease researchers' workload and provide results that are more reliable. In this work our goal was to write software that automatically segments human cardiomyocytes from images, calculates their areas and variations in the direction of the largest and smallest spread. **Results** We developed software that eased the workload of biomedical laboratory personnel such that they do not have to do manual image segmentation or learn to use software that requires programming skills. The software made a correct segmentation in most of the cases and outperformed the intensity oriented baseline method written in ImageJ in 95% of comparisons. The baseline method estimated cell- and background areas by averaging dark background and bright foreground areas. **Conclusions** Our software can be used in the calculation of cell areas and extents in the case where immunolabeled cells are imaged with a fluorescent microscope. In the future the functionality of the program could be extended with machine learning methods that use the user actions as teaching material in the cases where automatic segmentation fails.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Tampere University Hospital, BioMediTech

Contributors: Rasku, J., Ojala, M., Pölönen, R. P., Joutsijoki, H., Gizatdinova, Y., Laurikkala, J., Kartasalo, K., Aalto-Setälä, K., Juhola, M.

Number of pages: 6

Pages: 134-139

Publication date: 1 Sep 2016

Peer-reviewed: Yes

#### **Publication information**

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Scopus rating (2016): CiteScore 4.6 SJR 0.674 SNIP 1.725

Original language: English

ASJC Scopus subject areas: Health Informatics, Signal Processing

Keywords: Cardiomyocyte, Segmentation, Threshold

DOIs:

10.1016/j.bspc.2016.06.011

Source: Scopus

Source ID: 84978280164

Research output: Contribution to journal › Article › Scientific › peer-review

### **Nyström-based approximate kernel subspace learning**

In this paper, we describe a method for the determination of a subspace of the feature space in kernel methods, which is suited to large-scale learning problems. Linear model learning in the obtained space corresponds to a nonlinear model learning process in the input space. Since the obtained feature space is determined only by exploiting properties of the training data, this approach can be used for generic nonlinear pattern recognition. That is, nonlinear data mapping can be considered to be a pre-processing step exploiting nonlinear relationships between the training data. Linear techniques can be subsequently applied in the new feature space and, thus, they can model nonlinear properties of the problem at hand. In order to appropriately address the inherent problem of kernel learning methods related to their time and memory complexities, we follow an approximate learning approach. We show that the method can lead to considerable operation speed gains and achieve very good performance. Experimental results verify our analysis.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Video, Research Community on Data-to-Decision (D2D)

Contributors: Iosifidis, A., Gabbouj, M.  
Number of pages: 8  
Pages: 190-197  
Publication date: Sep 2016  
Peer-reviewed: Yes

#### Publication information

Journal: Pattern Recognition  
ISSN (Print): 0031-3203  
Ratings:

Scopus rating (2016): CiteScore 9 SJR 1.501 SNIP 3.005

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing

Keywords: Kernel methods, Nonlinear pattern recognition, Nonlinear projection trick, Nyström approximation

DOIs:

10.1016/j.patcog.2016.03.018

Source: Scopus

Source ID: 85013223573

Research output: Contribution to journal > Article > Scientific > peer-review

#### Compressive Detection of Random Subspace Signals

The problem of compressive detection of random subspace signals is studied. We consider signals modeled as  $s = Hx$  where  $H$  is an  $N \times K$  matrix with  $K \leq N$  and  $x \sim N(0, \frac{1}{\sigma^2} I_K)$ . We say that signal  $s$  lies in or leans toward a subspace if the largest eigenvalue of  $HH^T$  is strictly greater than its smallest eigenvalue. We first design a measurement matrix  $\Phi = [\Phi_s, \Phi_o]$  comprising of two sub-matrices  $\Phi_s$  and  $\Phi_o$  where  $\Phi_s$  projects the signal to the strongest left-singular vectors, i.e., the left-singular vectors corresponding to the largest singular values, of subspace matrix  $H$  and  $\Phi_o$  projects it to the weakest left-singular vectors. We then propose two detectors that work based on the difference in energies of the samples measured by the two sub-matrices  $\Phi_s$  and  $\Phi_o$  and provide theoretical proofs for their optimality. Simplified versions of the proposed detectors for the case when the variance of noise is known are also provided. Furthermore, we study the performance of the detector when measurements are imprecise and show how imprecision can be compensated by employing more measurement devices. The problem is then re-formulated for the generalized case when the signal lies in the union of a finite number of linear subspaces instead of a single linear subspace. Finally, we study the performance of the proposed methods by simulation examples.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Electrical Engineering Department, University of California, Los Angeles (UCLA)

Contributors: Razavi, A., Valkama, M., Cabric, D.

Number of pages: 14

Pages: 4166-4179

Publication date: 15 Aug 2016

Peer-reviewed: Yes

#### Publication information

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ISSN (Print): 1053-587X

Ratings:

Scopus rating (2016): CiteScore 8.7 SJR 1.385 SNIP 2.627

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing

Keywords: Compressive detection, F -distribution, hypothesis testing, random subspace signals, unknown noise variance

DOIs:

10.1109/TSP.2016.2560132

Source: Scopus

Source ID: 84980329115

Research output: Contribution to journal > Article > Scientific > peer-review

#### Variance Stabilization for Noisy+Estimate Combination in Iterative Poisson Denoising

We denoise Poisson images with an iterative algorithm that progressively improves the effectiveness of variance-stabilizing transformations (VST) for Gaussian denoising filters. At each iteration, a combination of the Poisson observations with the denoised estimate from the previous iteration is treated as scaled Poisson data and filtered through



a VST scheme. Due to the slight mismatch between a true scaled Poisson distribution and this combination, a special exact unbiased inverse is designed. We present an implementation of this approach based on the BM3D Gaussian denoising filter. With a computational cost at worst twice that of the noniterative scheme, the proposed algorithm provides significantly better quality, particularly at low signal-to-noise ratio, outperforming much costlier state-of-the-art alternatives.

#### General information

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Department of Signal Processing, Research group: Signal and Image Restoration-RST  
Contributors: Azzari, L., Foi, A.  
Number of pages: 5  
Pages: 1086-1090  
Publication date: 1 Aug 2016  
Peer-reviewed: Yes

#### Publication information

Journal: IEEE Signal Processing Letters  
Volume: 23  
Issue number: 8  
ISSN (Print): 1070-9908  
Ratings:  
Scopus rating (2016): CiteScore 5.3 SJR 0.798 SNIP 1.806  
Original language: English  
ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics  
Keywords: Anscombe transformation, image denoising, iterative filtering, photon-limited imaging, Poisson noise  
Electronic versions:  
post-print  
DOIs:  
10.1109/LSP.2016.2580600  
URLs:  
<http://urn.fi/URN:NBN:fi:itty-201608234436>  
Additional files:  
Supplementary materials  
Source: Scopus  
Source ID: 84979891796  
Research output: Contribution to journal > Article > Scientific > peer-review

#### Optimization of Flexible Filter Banks Based on Fast Convolution

Multirate filter banks can be implemented efficiently using fast-convolution (FC) processing. The main advantage of the FC filter banks (FC-FB) compared with the conventional polyphase implementations is their increased flexibility, that is, the number of channels, their bandwidths, and the center frequencies can be independently selected. In this paper, an approach to optimize the FC-FBs is proposed. First, a subband representation of the FC-FB is derived. Then, the optimization problems are formulated with the aid of the subband model. Finally, these problems are conveniently solved with the aid of a general nonlinear optimization algorithm. Several examples are included to demonstrate the proposed overall design scheme as well as to illustrate the efficiency and the flexibility of the resulting FC-FB.

#### General information

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning  
Contributors: Yli-Kaakinen, J., Renfors, M.  
Pages: 101-111  
Publication date: Aug 2016  
Peer-reviewed: Yes

#### Publication information

Journal: Journal of Signal Processing Systems  
Volume: 85  
Issue number: 1  
ISSN (Print): 1939-8018  
Ratings:  
Scopus rating (2016): CiteScore 1.6 SJR 0.212 SNIP 0.677  
Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Modelling and Simulation, Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science

Keywords: Digital filters, Filter banks, Multirate signal processing, Optimization, Sampling rate conversion

DOIs:

10.1007/s11265-015-1004-6

Source: Scopus

Source ID: 84929682954

Research output: Contribution to journal › Article › Scientific › peer-review

### Visual Voice Activity Detection in the Wild

The visual voice activity detection (V-VAD) problem in unconstrained environments is investigated in this paper. A novel method for V-VAD in the wild, exploiting local shape and motion information appearing at spatiotemporal locations of interest for facial video segment description and the bag of words model for facial video segment representation, is proposed. Facial video segment classification is subsequently performed using the state-of-The-Art classification algorithms. Experimental results on one publicly available V-VAD dataset denote the effectiveness of the proposed method, since it achieves better generalization performance in unseen users, when compared to the recently proposed state-of-The-Art methods. Additional results on a new unconstrained dataset provide evidence that the proposed method can be effective even in such cases in which any other existing method fails.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Aristotle University of Thessaloniki

Contributors: Patrona, F., Iosifidis, A., Tefas, A., Nikolaidis, N., Pitas, I.

Number of pages: 11

Pages: 967-977

Publication date: 1 Jun 2016

Peer-reviewed: Yes

### Publication information

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Volume: 18

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ISSN (Print): 1520-9210

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Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Media Technology, Computer Science Applications

Keywords: Action Recognition, Bag of Words model, Voice Activity Detection in the wild

DOIs:

10.1109/TMM.2016.2535357

Source: Scopus

Source ID: 84971281783

Research output: Contribution to journal › Article › Scientific › peer-review

### Rotation Invariant Texture Description Using Symmetric Dense Microblock Difference

This letter is devoted to the problem of rotation invariant texture classification. Novel rotation invariant feature, symmetric dense microblock difference (SDMD), is proposed which captures the information at different orientations and scales. N-fold symmetry is introduced in the feature design configuration, while retaining the random structure that provides discriminative power. The symmetry is utilized to achieve a rotation invariance. The SDMD is extracted using an image pyramid and encoded by the Fisher vector approach resulting in a descriptor which captures variations at different resolutions without increasing the dimensionality. The proposed image representation is combined with the linear SVM classifier. Extensive experiments are conducted on four texture data sets [Brodatz, UMD, UIUC, and Flickr material data set (FMD)] using standard protocols. The results demonstrate that our approach outperforms the state of the art in texture classification. The MATLAB code is made available.<sup>1</sup> Matlab Code: <http://www.cs.tut.fi/~mehta/symdmd>.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Computational Imaging-CI

Contributors: Mehta, R., Egiazarian, K.

Number of pages: 5

Pages: 833-837

Publication date: 1 Jun 2016

Peer-reviewed: Yes

### Publication information

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Volume: 23

Issue number: 6

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2016): CiteScore 5.3 SJR 0.798 SNIP 1.806

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics

Keywords: image representation, local features, Rotation invariant features, texture classification

DOIs:

10.1109/LSP.2016.2561311

Source: Scopus

Source ID: 84970004897

Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### A Wideband Front-End Receiver Implementation on GPUs

Modern communication systems have frequency bands that are shared with multiple channels. A typical front-end transceiver is responsible for processing multiple channels simultaneously within the band. Although it is simpler to design a dedicated sub-transceiver for each channel, the overall cost of implementation is prohibitive. It is more desirable to design a single system that can process many channels at the same time. However, it is difficult to realize such a transceiver in wireless communication systems, since it needs to accommodate different standards, data rates, sampling rates, etc. In this paper, we address the challenges of flexible, cost-effective, multi-channel implementation of wideband receiver systems. In particular, we develop a novel implementation by applying graphics processing unit (GPU) technology to a wideband receiver that processes multiple channels at the same time, including channelization and arbitrary resampling. Our proposed new receiver architecture is flexible and reconfigurable via software, while providing high throughput and low latency.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Pervasive Computing, Research area: Computer engineering, University of Maryland, Department of Electrical and Computer Engineering

Contributors: Kim, S. C., Bhattacharyya, S. S.

Number of pages: 11

Pages: 2602-2612

Publication date: 15 May 2016

Peer-reviewed: Yes

### Publication information

Journal: IEEE Transactions on Signal Processing

Volume: 64

Issue number: 10

ISSN (Print): 1053-587X

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Scopus rating (2016): CiteScore 8.7 SJR 1.385 SNIP 2.627

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing

Keywords: Arbitrary resampler, carrier aggregation, GPU front-end receiver, GPU-based radio, Polyphase channelizer

DOIs:

10.1109/TSP.2016.2535349

Source: Scopus

Source ID: 84968750704

Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### Statistical analysis of interference for nanoscale electromechanical wireless communication at VHF-band

Nanoscale electromechanical wireless communication with on-off keying in the very high frequency (VHF) band (30-300 MHz) is studied for a receiver using a carbon nanotube (CNT). Previous studies on this topic have only considered continuous wave (CW) on-off keying which suffers from spectral widening due to sharp changes in the signal. Effects of the inter-symbol interference (ISI), the co-channel interference, and the adjacent channel interference on the received signal statistics have not been analyzed. The rise- and fall-times associated with the filtering of the incoming signal by the mechanical frequency response of the receiver's CNT have also been ignored. In this paper, Fourier-series based

modeling and statistical analysis of decision variables are performed. The results and modeling in this study enable performance evaluation of CNT based receivers with an arbitrary number of interfering signals with arbitrary pulse shapes, and fully incorporates the transient signal components. Received signal statistics under interference are derived using the developed model. Numerical results are presented for Hanning pulse and trapezoidal pulse (which includes rectangular pulses corresponding to CW as a special case). The required guard intervals between pulses to mitigate ISI, required frequency separation between channels, and required spatial separation of co-channel networks (frequency reuse distance) are shown. These results show that large frequency reuse distance is required, limiting efficient spectrum utilization. However, the ISI and adjacent channel interference can be controlled more easily with a proper selection of parameters.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, University of Oulu, Georgia Institute of Technology, School of Electrical and Computer Engineering, Nano Communication Centre, Aristotle University of Thessaloniki, School of Electrical and Computer Engineering

Contributors: Lehtomäki, J. J., Bicen, A. O., Akyildiz, I. F.

Number of pages: 11

Pages: 2040-2050

Publication date: 15 Apr 2016

Peer-reviewed: Yes

### Publication information

Journal: IEEE Transactions on Signal Processing

Volume: 64

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ISSN (Print): 1053-587X

Ratings:

Scopus rating (2016): CiteScore 8.7 SJR 1.385 SNIP 2.627

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing

Keywords: Carbon nanotube, frequency division multiple access, nanodevice, nanonetwork, on-off keying, VHF-band, wireless communication

DOIs:

10.1109/TSP.2015.2512526

### Bibliographical note

INT=elt,"Bicen, A. Ozan"

Source: Scopus

Source ID: 84964402214

Research output: Contribution to journal > Article > Scientific > peer-review

### Which wavelength is the best for arterial pulse waveform extraction using laser speckle imaging?

A multi-wavelengths analysis for pulse waveform extraction using laser speckle is conducted. The proposed system consists of three coherent light sources (532 nm, 635 nm, 850 nm). A bench-test composed of a moving skin-like phantom (silicone membrane) is used to compare the results obtained from different wavelengths. The system is able to identify a skin-like phantom vibration frequency, within physiological values, with a minimum error of 0.5 mHz for the 635 nm and 850 nm wavelengths and a minimum error of 1.3 mHz for the 532 nm light wavelength using a FFT-based algorithm. The phantom velocity profile is estimated with an error ranging from 27% to 9% using a bidimensional correlation coefficient-based algorithm. An in vivo trial is also conducted, using the 532 nm and 635 nm laser sources. The 850 nm light source has not been able to extract the pulse waveform. The heart rate is identified with a minimum error of 0.48 beats per minute for the 532 nm light source and a minimal error of 1.15 beats per minute for the 635 nm light source. Our work reveals that a laser speckle-based system with a 532 nm wavelength is able to give arterial pulse waveform with better results than those given with a 635 nm laser.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Computational Biophysics and Imaging Group, LARIS-Laboratoire Angevin de Recherche en Ingénierie des Systèmes, Center for Mathematics Probability and Statistics

Contributors: Vaz, P., Pereira, T., Figueiras, E., Correia, C., Humeau-Heurtier, A., Cardoso, J.

Number of pages: 8

Pages: 188-195

Publication date: Mar 2016

Peer-reviewed: Yes

### Publication information

Journal: Biomedical Signal Processing and Control

Volume: 25

ISSN (Print): 1746-8094

Ratings:

Scopus rating (2016): CiteScore 4.6 SJR 0.674 SNIP 1.725

Original language: English

ASJC Scopus subject areas: Health Informatics, Signal Processing

Keywords: Arterial pulse waveform, Correlation, Fast Fourier transform, Laser speckle, Multi-spectral

DOIs:

10.1016/j.bspc.2015.11.013

Source: Scopus

Source ID: 84950341719

Research output: Contribution to journal › Article › Scientific › peer-review

### Importance of maintenance data quality in extended warranty simulation

As manufacturing industries are transforming towards service orientation, predicting the costs of product-service systems is becoming essential. Simulation is one possibility for evaluating the costs and risks involved in product-service systems, such as extended warranty agreements. We conducted a case study with a globally operating manufacturer of industrial goods who also provides services for the equipment. We created equipment performance simulation (EPSi) models and a tool, EPSitor, for using the models in predicting extended warranty costs. However, reliable simulation results require good quality maintenance and operation data from existing installations. We discovered that it is difficult to collect the data needed for simulations and there were many challenges with data quality. Quality problems were mainly observed in manually collected data. Insufficient data quality leads to a wider margin of error in the simulation models, which increases business risk. Identifying these challenges is the first step in transforming the data collection routines to support equipment performance simulations. The key to long-term business benefits of simulation is to acknowledge the importance of data quality and to establish efficient data collection routines. Future research should find ways to motivate maintenance technicians to collect good quality data. This would contribute to more accurate cost analysis and thus to better profitability of extended warranty contracts.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Mechanical Engineering and Industrial Systems, Research group: Käyttövarmuuden suunnittelu ja kunnossapito, Research area: Life-cycle Management, Aalto University

Contributors: Mahlamäki, K., Niemi, A., Jokinen, J., Borgman, J.

Number of pages: 8

Pages: 3-10

Publication date: 1 Jan 2016

Peer-reviewed: Yes

### Publication information

Journal: International Journal of COMADEM

Volume: 19

Issue number: 1

ISSN (Print): 1363-7681

Ratings:

Scopus rating (2016): CiteScore 0.2 SJR 0.128 SNIP 0.163

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Industrial and Manufacturing Engineering, Safety, Risk, Reliability and Quality, Bioengineering, Signal Processing, Strategy and Management

Keywords: Asset management, Data quality, Hitman factors

URLs:

<http://www.scopus.com/inward/record.url?scp=84960940492&partnerID=8YFLogxK> (Link to publication in Scopus)

### Bibliographical note

INT=mei,"Jokinen, Juuso"

Source: Scopus

Source ID: 84960940492

Research output: Contribution to journal › Article › Scientific › peer-review

### **Online tests of Kalman filter consistency**

The normalised innovation squared (NIS) test, which is used to assess whether a Kalman filter's noise assumptions are consistent with realised measurements, can be applied online with real data, and does not require future data, repeated experiments or knowledge of the true state. In this work, it is shown that the NIS test is equivalent to three other model criticism procedures, which are as follows: (i) it can be derived as a Bayesian p-test for the prior predictive distribution; (ii) as a nested-model parameter significance test; and (iii) from a recently-proposed filter residual test. A new NIS-like test corresponding to a posterior predictive Bayesian p-test is presented.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Automation Science and Engineering, Research group: Positioning

Contributors: Piché, R.

Pages: 115–124

Publication date: 2016

Peer-reviewed: Yes

### **Publication information**

Journal: International Journal of Adaptive Control and Signal Processing

Volume: 30

Issue number: 1

ISSN (Print): 0890-6327

Ratings:

Scopus rating (2016): CiteScore 3.8 SJR 0.749 SNIP 1.023

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Electrical and Electronic Engineering, Signal Processing

Keywords: Kalman filter, Model consistency, Normalised innovations squared, Predictive distribution

Electronic versions:

KFconsistency2015

DOIs:

10.1002/acs.2571

URLs:

<http://urn.fi/URN:NBN:fi:ty-201603173659>

Source: Scopus

Source ID: 84954027695

Research output: Contribution to journal › Article › Scientific › peer-review

### **Still image/video frame lossy compression providing a desired visual quality**

The problem of how to automatically provide a desired (required) visual quality in lossy compression of still images and video frames is considered in this paper. The quality can be measured based on different conventional and visual quality metrics. In this paper, we mainly employ human visual system (HVS) based metrics PSNR-HVS-M and MSSIM since both of them take into account several important peculiarities of HVS. To provide a desired visual quality with high accuracy, iterative image compression procedures are proposed and analyzed. An experimental study is performed for a large number of grayscale test images. We demonstrate that there exist several coders for which the number of iterations can be essentially decreased using a reasonable selection of the starting value and the variation interval for the parameter controlling compression (PCC). PCC values attained at the end of the iterative procedure may heavily depend upon the coder used and the complexity of the image. Similarly, the compression ratio also considerably depends on the above factors. We show that for some modern coders that take HVS into consideration it is possible to give practical recommendations on setting a fixed PCC to provide a desired visual quality in a non-iterative manner. The case when original images are corrupted by visible noise is also briefly studied.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Computational Imaging-CI, National Aerospace University

Contributors: Zemliachenko, A., Lukin, V., Ponomarenko, N., Egiazarian, K., Astola, J.

Pages: 697-718

Publication date: 2016

Peer-reviewed: Yes

### **Publication information**

Journal: Multidimensional Systems and Signal Processing

Volume: 27

Issue number: 3

ISSN (Print): 0923-6082

Ratings:

Scopus rating (2016): CiteScore 3.4 SJR 0.424 SNIP 1.109

Original language: English

ASJC Scopus subject areas: Computer Science Applications, Information Systems, Signal Processing, Software, Artificial Intelligence, Hardware and Architecture, Applied Mathematics

Keywords: Compression ratio, Lossy compression, Required quality, Visual quality metrics

DOIs:

10.1007/s11045-015-0333-8

URLs:

<http://www.scopus.com/inward/record.url?scp=84930357751&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84930357751

Research output: Contribution to journal › Article › Scientific › peer-review

### IEEE 802.11ac MIMO Transceiver Baseband Processing on a VLIW Processor

Wireless standards are evolving rapidly due to the exponential growth in the number of portable devices along with the applications with high data rate requirements. Adaptable software based signal processing implementations for these devices can make the deployment of the constantly evolving standards faster and less expensive. The flagship technology from the IEEE WLAN family, the IEEE 802.11ac, aims at achieving very high throughputs in local area connectivity scenarios. This article presents a software based implementation for the Multiple Input and Multiple Output (MIMO) transmitter and receiver baseband processing conforming to the IEEE 802.11ac standard which can achieve transmission bit rates beyond 1Gbps. This work focuses on the Physical layer frequency domain processing. Various configurations, including 2x2 and 4x4 MIMO are considered for the implementation. To utilize the available data and instruction level parallelism, a DSP core with vector extensions is selected as the implementation platform. Then, the feasibility of the presented software-based solution is assessed by studying the number of clock cycles and power consumption of the different scenarios implemented on this core. Such Software Defined Radio based approaches can potentially offer more flexibility, high energy efficiency, reduced design efforts and thus shorter time-to-market cycles in comparison with the conventional fixed-function hardware methods.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Department of Pervasive Computing, Research area: Computer engineering

Contributors: Aghababaeetafreshi, M., Lehtonen, L. K., Levanen, T., Valkama, M., Takala, J.

Publication date: 2016

Peer-reviewed: Yes

#### Publication information

Journal: Journal of Signal Processing Systems

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2016): CiteScore 1.6 SJR 0.212 SNIP 0.677

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Modelling and Simulation, Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science

Keywords: MIMO, OFDM, Parallel processing, Software defined radio, VLIW, WLAN

DOIs:

10.1007/s11265-015-1032-2

URLs:

<http://www.scopus.com/inward/record.url?scp=84942023616&partnerID=8YFLogxK> (Link to publication in Scopus)

#### Bibliographical note

ORG=elt,0.5

ORG=tie,0.5

Source: Scopus

Source ID: 84942023616

Research output: Contribution to journal › Article › Scientific › peer-review

### Instrumentation-Driven Validation of Dataflow Applications

Dataflow modeling offers a myriad of tools for designing and optimizing signal processing systems. A designer is able to take advantage of dataflow properties to effectively tune the system in connection with functionality and different performance metrics. However, a disparity in the specification of dataflow properties and the final implementation can lead

to incorrect behavior that is difficult to detect. This motivates the problem of ensuring consistency between dataflow properties that are declared or otherwise assumed as part of dataflow-based application models, and the dataflow behavior that is exhibited by implementations that are derived from the models. In this paper, we address this problem by introducing a novel dataflow validation framework (DVF) that is able to identify disparities between an application's formal dataflow representation and its implementation. DVF works by instrumenting the implementation of an application and monitoring the instrumentation data as the application executes. This monitoring process is streamlined so that DVF achieves validation without major overhead. We demonstrate the utility of our DVF through design and implementation case studies involving an automatic speech recognition application, a JPEG encoder, and an acoustic tracking application.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Pervasive Computing, Research area: Computer engineering, Signal Processing Research Community (SPRC), University of Maryland, Technische Universitat Munchen, Institute for Advanced Computer Studies

Contributors: Chukhman, I., Jiao, Y., Salem, H. B., Bhattacharyya, S. S.

Pages: 383–397

Publication date: 2016

Peer-reviewed: Yes

### Publication information

Journal: Journal of Signal Processing Systems

Volume: 84

Issue number: 3

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2016): CiteScore 1.6 SJR 0.212 SNIP 0.677

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Modelling and Simulation, Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science

Keywords: Dataflow graphs, Design validation, Models of computation, Signal processing systems

DOIs:

10.1007/s11265-015-1073-6

Source: Scopus

Source ID: 84946128443

Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### Dominant Rotated Local Binary Patterns (DRLBP) for texture classification

In this paper, we present a novel rotation-invariant and computationally efficient texture descriptor called Dominant Rotated Local Binary Pattern (DRLBP). A rotation invariance is achieved by computing the descriptor with respect to a reference in a local neighborhood. A reference is fast to compute maintaining the computational simplicity of the Local Binary Patterns (LBP). The proposed approach not only retains the complete structural information extracted by LBP, but it also captures the complimentary information by utilizing the magnitude information, thereby achieving more discriminative power. For feature selection, we learn a dictionary of the most frequently occurring patterns from the training images, and discard redundant and non-informative features. To evaluate the performance we conduct experiments on three standard texture datasets: Outex12, Outex 10 and KTH-TIPS. The performance is compared with the state-of-the-art rotation invariant texture descriptors and results show that the proposed method is superior to other approaches.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Computational Imaging-CI

Contributors: Mehta, R., Egiazarian, K.

Number of pages: 7

Pages: 16-22

Publication date: 2016

Peer-reviewed: Yes

Early online date: 30 Nov 2015

### Publication information

Journal: Pattern Recognition Letters

Volume: 71

ISSN (Print): 0167-8655

Ratings:

Scopus rating (2016): CiteScore 5.2 SJR 0.729 SNIP 1.678

Original language: English



ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing  
Keywords: Feature Selection, KTH-TIPS, Local Binary Pattern (LBP), Outex, Rotation Invariance, Texture Classification  
DOIs:

10.1016/j.patrec.2015.11.019

Source: Scopus

Source ID: 84951106920

Research output: Contribution to journal › Article › Scientific › peer-review

### **Efficiency of texture image filtering and its prediction**

Textures are typical elements of natural scene images widely used in pattern recognition and image classification. Noise, often being present in acquired images, deteriorates texture features (characteristics), and it is desirable both to suppress it and to preserve a texture. This task is quite difficult even for the most advanced filters, and the resulting denoising efficiency can be quite low. Due to this, it is desirable to predict a denoising efficiency before filtering to decide whether it is worth filtering a given image or not. In this paper, we analyze several quantitative criteria (metrics) that can characterize filtering efficiency. Prediction strategy is described and its accuracy is studied. Several modern filtering techniques are analyzed and compared. Based on this, practical recommendations are given.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Kharkiv National Aerospace University, Universite de Rennes, Instituto Politecnico Nacional

Contributors: Rubel, O., Lukin, V., Abramov, S., Vozel, B., Egiazarian, K., Pogrebnyak, O.

Number of pages: 8

Pages: 1543–1550

Publication date: 2016

Peer-reviewed: Yes

### **Publication information**

Journal: Signal, Image and Video Processing

Volume: 10

Issue number: 8

ISSN (Print): 1863-1703

Ratings:

Scopus rating (2016): CiteScore 2.4 SJR 0.373 SNIP 1.118

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing

Keywords: Filtering efficiency, Image enhancement, Noise suppression, Visual quality

DOIs:

10.1007/s11760-016-0969-3

Source: Scopus

Source ID: 84983806396

Research output: Contribution to journal › Article › Scientific › peer-review

### **Unbiased Injection of Signal-Dependent Noise in Variance-Stabilized Range**

The design, optimization, and validation of many image processing or image-based analysis systems often requires testing of the system performance over a dataset of images corrupted by noise at different signal-to-noise ratio regimes. A noise-free ground-truth image may not be available, and different SNRs are simulated by injecting extra noise into an already noisy image. However, noise in real-world systems is typically signal-dependent, with variance determined by the noise-free image. Thus, also the noise to be injected shall depend on the unknown ground-truth image. To circumvent this issue, we consider the additive injection of noise in variance-stabilized range, where no previous knowledge of the ground-truth signal is necessary. Specifically, we design a special noise-injection operator that prevents the errors on expectation and variance that would otherwise arise when standard variance-stabilizing transformations are used for this task. Thus, the proposed operator is suitable for accurately injecting signal-dependent noise even to images acquired at very low counts.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Signal and Image Restoration-RST, Department of Applied Physics

Contributors: Borges, L., Vieira, M., Foi, A.

Pages: 1494–1498

Publication date: 2016

Peer-reviewed: Yes

### Publication information

Journal: IEEE Signal Processing Letters

Volume: 23

Issue number: 10

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2016): CiteScore 5.3 SJR 0.798 SNIP 1.806

Original language: English

ASJC Scopus subject areas: Signal Processing, Applied Mathematics, Electrical and Electronic Engineering

Keywords: Anscombe transformation, Noise injection, optimization, Poisson noise, variance stabilization

Electronic versions:

UnbiasedNoiseInjection2016

DOIs:

10.1109/LSP.2016.2601689

URLs:

<http://urn.fi/URN:NBN:fi:tty-201610214624>

Source: Scopus

Source ID: 85027556734

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### Using multi-step proposal distribution for improved MCMC convergence in Bayesian network structure learning

Bayesian networks have become popular for modeling probabilistic relationships between entities. As their structure can also be given a causal interpretation about the studied system, they can be used to learn, for example, regulatory relationships of genes or proteins in biological networks and pathways. Inference of the Bayesian network structure is complicated by the size of the model structure space, necessitating the use of optimization methods or sampling techniques, such as Markov Chain Monte Carlo (MCMC) methods. However, convergence of MCMC chains is in many cases slow and can become even a harder issue as the dataset size grows. We show here how to improve convergence in the Bayesian network structure space by using an adjustable proposal distribution with the possibility to propose a wide range of steps in the structure space, and demonstrate improved network structure inference by analyzing phosphoprotein data from the human primary T cell signaling network.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Aalto University, Department of Computer Science and Information Systems

Contributors: Larjo, A., Lähdesmäki, H.

Publication date: 27 Dec 2015

Peer-reviewed: Yes

### Publication information

Journal: Eurasip Journal on Bioinformatics and Systems Biology

Volume: 2015

Issue number: 1

Article number: 6

ISSN (Print): 1687-4145

Ratings:

Scopus rating (2015): CiteScore 1.8 SJR 0.314 SNIP 0.371

Original language: English

ASJC Scopus subject areas: Medicine(all), Computer Science(all), Signal Processing, Statistics and Probability, General

Keywords: Bayesian network, MCMC, Proposal distribution, Structure learning

DOIs:

10.1186/s13637-015-0024-7

### Bibliographical note

EXT="Lähdesmäki, Harri"

Source: Scopus

Source ID: 84932633872

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### **Energy cooperation for throughput optimization based on save-then-transmit protocol in wireless communication system**

Green communication and energy saving have been a critical issue in modern wireless communication systems. The concepts of energy harvesting and energy transfer are recently receiving much attention in academic research field. In this paper, we study energy cooperation problems based on save-then-transmit protocol and propose two energy cooperation schemes for different system models: two-node communication model and three-node relay communication model. In both models, all of the nodes transmitting information have no fixed energy supplies and gain energy only via wireless energy harvesting from nature. Besides, these nodes also follow a save-then-transmit protocol. Namely, for each timeslot, a fraction (referred to as save-ratio) of time is devoted exclusively to energy harvesting while the remaining fraction is used for data transmission. In order to maximize the system throughput, energy transfer mechanism is introduced in our schemes, i.e., some nodes are permitted to share their harvested energy with other nodes by means of wireless energy transfer. Simulation results demonstrate that our proposed schemes can outperform both the schemes with half-allocate save-ratio and the schemes without energy transfer in terms of throughput performance, and also characterize the dependencies of system throughput, transferred energy, and save-ratio on energy harvesting rate.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Chongqing Key Lab of Mobile Communication Technology, Chongqing University of Posts and Telecommunications

Contributors: Dai, C., Li, F., Renfors, M.

Publication date: 26 Dec 2015

Peer-reviewed: Yes

#### **Publication information**

Journal: Eurasip Journal on Wireless Communications and Networking

Volume: 2015

Issue number: 1

Article number: 119

ISSN (Print): 1687-1472

Ratings:

Scopus rating (2015): CiteScore 2.7 SJR 0.362 SNIP 1.138

Original language: English

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Computer Science

Applications

Keywords: Energy harvesting, Energy transfer, Save-then-transmit protocol, Throughput optimization

DOIs:

10.1186/s13638-015-0364-8

URLs:

<http://www.scopus.com/inward/record.url?scp=84930207810&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84930207810

Research output: Contribution to journal › Article › Scientific › peer-review

### **Generative part-based Gabor object detector**

Discriminative part-based models have become the approach for visual object detection. The models learn from a large number of positive and negative examples with annotated class labels and location (bounding box). In contrast, we propose a part-based generative model that learns from a small number of positive examples. This is achieved by utilizing "privileged information", sparse class-specific landmarks with semantic meaning. Our method uses bio-inspired complex-valued Gabor features to describe local parts. Gabor features are transformed to part probabilities by unsupervised Gaussian Mixture Model (GMM). GMM estimation is robustified for a small amount of data by a randomization procedure inspired by random forests. The GMM framework is also used to construct a probabilistic spatial model of part configurations. Our detector is invariant to translation, rotation and scaling. On part level invariance is achieved by pose quantization which is more efficient than previously proposed feature transformations. In the spatial model, invariance is achieved by mapping parts to an "aligned object space". Using a small number of positive examples our generative method performs comparably to the state-of-the-art discriminative method.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Vision, Field robotics for efficient work sites (FIRE), Prostate cancer research center (PCRC), Lappeenranta University of Technology

Contributors: Riabchenko, E., Kämäräinen, J.

Number of pages: 8

Pages: 1-8

Publication date: 15 Dec 2015

Peer-reviewed: Yes

### Publication information

Journal: Pattern Recognition Letters

Volume: 68

Issue number: P1

ISSN (Print): 0167-8655

Ratings:

Scopus rating (2015): CiteScore 5.1 SJR 0.95 SNIP 2.002

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing

Keywords: Gabor feature, Gaussian mixture model, Generative learning, Object detection, Visual classification

DOIs:

10.1016/j.patrec.2015.08.004

### Bibliographical note

EXT="Riabchenko, Ekaterina"

Source: Scopus

Source ID: 84941570575

Research output: Contribution to journal › Article › Scientific › peer-review

### Binomial Gaussian mixture filter

In this work, we present a novel method for approximating a normal distribution with a weighted sum of normal distributions. The approximation is used for splitting normally distributed components in a Gaussian mixture filter, such that components have smaller covariances and cause smaller linearization errors when nonlinear measurements are used for the state update. Our splitting method uses weights from the binomial distribution as component weights. The method preserves the mean and covariance of the original normal distribution, and in addition, the resulting probability density and cumulative distribution functions converge to the original normal distribution when the number of components is increased. Furthermore, an algorithm is presented to do the splitting such as to keep the linearization error below a given threshold with a minimum number of components. The accuracy of the estimate provided by the proposed method is evaluated in four simulated single-update cases and one time series tracking case. In these tests, it is found that the proposed method is more accurate than other Gaussian mixture filters found in the literature when the same number of components is used and that the proposed method is faster and more accurate than particle filters.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Automation Science and Engineering, Department of Mathematics, Research group: MAT

Positioning, Research group: Positioning, Wireless Communications and Positioning (WICO)

Contributors: Raitoharju, M., Ali-Löytty, S., Piché, R.

Publication date: 2 Dec 2015

Peer-reviewed: Yes

### Publication information

Journal: Eurasip Journal on Advances in Signal Processing

Volume: 2015

Issue number: 1

Article number: 36

ISSN (Print): 1687-6172

Ratings:

Scopus rating (2015): CiteScore 2.5 SJR 0.351 SNIP 0.942

Original language: English

ASJC Scopus subject areas: Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: Estimation, Gaussian mixture filter, Nonlinear filtering

Electronic versions:

s13634-015-0221-2

DOIs:

10.1186/s13634-015-0221-2

URLs:

<http://urn.fi/URN:NBN:fi:tty-201706051582>

URLs:

<http://www.scopus.com/inward/record.url?scp=84934283964&partnerID=8YFLogxK> (Link to publication in Scopus)

### Bibliographical note

ORG=ase,0.75

ORG=mat,0.25

Source: Scopus

Source ID: 84934283964

Research output: Contribution to journal › Article › Scientific › peer-review

### A fast universal self-tuned sampler within Gibbs sampling

Bayesian inference often requires efficient numerical approximation algorithms, such as sequential Monte Carlo (SMC) and Markov chain Monte Carlo (MCMC) methods. The Gibbs sampler is a well-known MCMC technique, widely applied in many signal processing problems. Drawing samples from univariate full-conditional distributions efficiently is essential for the practical application of the Gibbs sampler. In this work, we present a simple, self-tuned and extremely efficient MCMC algorithm which produces virtually independent samples from these univariate target densities. The proposal density used is self-tuned and tailored to the specific target, but it is not adaptive. Instead, the proposal is adjusted during an initial optimization stage, following a simple and extremely effective procedure. Hence, we have named the newly proposed approach as FUSS (Fast Universal Self-tuned Sampler), as it can be used to sample from any bounded univariate distribution and also from any bounded multi-variate distribution, either directly or by embedding it within a Gibbs sampler. Numerical experiments, on several synthetic data sets (including a challenging parameter estimation problem in a chaotic system) and a high-dimensional financial signal processing problem, show its good performance in terms of speed and estimation accuracy.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Industrial Management, Research group: Financial Engineering, Research Community on Data-to-Decision (D2D), Universidad Politecnica de Madrid

Contributors: Martino, L., Yang, H., Luengo, D., Kannianen, J., Corander, J.

Pages: 68-83

Publication date: 1 Dec 2015

Peer-reviewed: Yes

### Publication information

Journal: Digital Signal Processing

Volume: 47

ISSN (Print): 1051-2004

Ratings:

Scopus rating (2015): CiteScore 3.3 SJR 0.566 SNIP 1.368

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Adaptive rejection Metropolis sampling, Bayesian inference, Gibbs sampling, Markov Chain Monte Carlo (MCMC), Metropolis within Gibbs

DOIs:

10.1016/j.dsp.2015.04.005

URLs:

<http://www.scopus.com/inward/record.url?scp=84928191257&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84948117324

Research output: Contribution to journal › Article › Scientific › peer-review

### Kalman filter with a linear state model for PDR+WLAN positioning and its application to assisting a particle filter

Indoor positioning based on wireless local area network (WLAN) signals is often enhanced using pedestrian dead reckoning (PDR) based on an inertial measurement unit. The state evolution model in PDR is usually nonlinear. We present a new linear state evolution model for PDR. In simulated-data and real-data tests of tightly coupled WLAN-PDR positioning, the positioning accuracy with this linear model is better than with the traditional models when the initial heading is not known, which is a common situation. The proposed method is computationally light and is also suitable for smoothing. Furthermore, we present modifications to WLAN positioning based on Gaussian coverage areas and show how a Kalman filter using the proposed model can be used for integrity monitoring and (re)initialization of a particle filter.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Automation Science and Engineering, Research area: Dynamic Systems, Research group: Positioning, Wireless Communications and Positioning (WICO)

Contributors: Raitoharju, M., Nurminen, H., Piché, R.

Publication date: 1 Dec 2015

Peer-reviewed: Yes

### Publication information

Journal: Eurasip Journal on Advances in Signal Processing

Volume: 2015

Issue number: 1

Article number: 33

ISSN (Print): 1687-6172

Ratings:

Scopus rating (2015): CiteScore 2.5 SJR 0.351 SNIP 0.942

Original language: English

ASJC Scopus subject areas: Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: Computational modeling, Indoor positioning, Pedestrian dead reckoning, Wireless LAN

Electronic versions:

s13634-015-0216-z

DOIs:

10.1186/s13634-015-0216-z

URLs:

<http://urn.fi/URN:NBN:fi:tty-201706051578>

URLs:

<http://www.scopus.com/inward/record.url?scp=84928397748&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84928397748

Research output: Contribution to journal › Article › Scientific › peer-review

### A New Approach to Sign-Bit-Based Parameter Estimation in OFDM Receivers

This article combines algorithm development, thorough analysis and implementation of sign-bit (SB) estimation techniques for symbol timing, carrier frequency offset (CFO) and signal-to-noise ratio (SNR) in orthogonal frequency division multiplexing receivers. The SB estimation is compared in terms of performance and hardware complexity to an equivalent implementation with higher quantization. The techniques are demonstrated by simulation of a SB time/frequency and SB-SNR estimator for 3rd Generation Partnership Project long-term evolution (LTE) cell search in 65-nm technology operating at nominal voltage of 1.2 V. According to post-layout power simulations with toggling information, the architecture estimates the corresponding CFO and SNR for as little as  $479 \mu\text{W}$  average power for LTE-R8/10, while occupying a silicon area as small as  $0.03 \text{ mm}^2$ . Even though SB estimation experiences some relative performance penalty when compared to 8-bit quantization, this paper demonstrates various advantages and the potential of employing these techniques in low-complexity terminals.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Lund Univ, Lund University, Ericsson Research

Contributors: Diaz, I., Wilhelmsson, L. R., Sofotasios, P. C., Miao, Y., Tan, S., Edfors, O., Öwall, V.

Number of pages: 30

Pages: 3631-3660

Publication date: 23 Nov 2015

Peer-reviewed: Yes

### Publication information

Journal: Circuits, Systems and Signal Processing

Volume: 34

Issue number: 11

ISSN (Print): 0278-081X

Ratings:

Scopus rating (2015): CiteScore 2.7 SJR 0.506 SNIP 0.909

Original language: English

ASJC Scopus subject areas: Signal Processing, Applied Mathematics

Keywords: CFO, LTE, OFDM, Receiver design, SNR, Symbol timing, Time synchronization

DOIs:

10.1007/s00034-015-0025-5

Source: Scopus

Source ID: 84941992241

Research output: Contribution to journal › Article › Scientific › peer-review

### **Robust Inference for State-Space Models with Skewed Measurement Noise**

Filtering and smoothing algorithms for linear discrete-time state-space models with skewed and heavy-tailed measurement noise are presented. The algorithms use a variational Bayes approximation of the posterior distribution of models that have normal prior and skew-t-distributed measurement noise. The proposed filter and smoother are compared with conventional low-complexity alternatives in a simulated pseudorange positioning scenario. In the simulations the proposed methods achieve better accuracy than the alternative methods, the computational complexity of the filter being roughly 5 to 10 times that of the Kalman filter.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Automation Science and Engineering, Research group: Positioning, Wireless Communications and Positioning (WICO), Linköping University

Contributors: Nurminen, H., Ardeshiri, T., Piché, R., Gustafsson, F.

Number of pages: 5

Pages: 1898-1902

Publication date: 1 Nov 2015

Peer-reviewed: Yes

#### **Publication information**

Journal: IEEE Signal Processing Letters

Volume: 22

Issue number: 11

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2015): CiteScore 4.2 SJR 0.822 SNIP 1.798

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics

Keywords: Kalman filter, robust filtering, RTS smoother, skew t, skewness, t-distribution, variational Bayes

Electronic versions:

SPL2015\_final

DOIs:

10.1109/LSP.2015.2437456

URLs:

<http://urn.fi/URN:NBN:fi:ty-201603173652>

Source: Scopus

Source ID: 84933056939

Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### **Entropy and Channel Capacity under Optimum Power and Rate Adaptation over Generalized Fading Conditions**

Accurate fading characterization and channel capacity determination are of paramount importance in both conventional and emerging communication systems. The present work addresses the non-linearity of the propagation medium and its effects on the channel capacity. Such fading conditions are first characterized using information theoretic measures, namely, Shannon entropy, cross entropy and relative entropy. The corresponding effects on the channel capacity with and without power adaptation are then analyzed. Closed-form expressions are derived and validated through computer simulations. It is shown that the effects of nonlinearities are significantly larger than those of fading parameters such as the scattered-wave power ratio, and the correlation coefficient between the in-phase and quadrature components in each cluster of multipath components.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research group: Wireless Communications and Positioning, Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO), Department of Electrical Engineering and Computer Science, Aristotle University of Thessaloniki, Department of Electronic Engineering, Khalifa University,

Centre for Communication Systems Research, University of Surrey, University of Leeds, International University of Rabat

Contributors: Sofotasios, P. C., Muhaidat, S., Valkama, M., Ghogho, M., Karagiannidis, G. K.

Number of pages: 5

Pages: 2162-2166

Publication date: 1 Nov 2015

Peer-reviewed: Yes

#### **Publication information**

Journal: IEEE Signal Processing Letters

Volume: 22

Issue number: 11

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2015): CiteScore 4.2 SJR 0.822 SNIP 1.798

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics

Keywords: Adaptation policies, channel capacity, entropy

DOIs:

10.1109/LSP.2015.2464221

Source: Scopus

Source ID: 84939865476

Research output: Contribution to journal › Article › Scientific › peer-review

### **Sparse extreme learning machine classifier exploiting intrinsic graphs**

This paper presents an analysis of the recently proposed sparse extreme learning machine (S-ELM) classifier and describes an optimization scheme that can be used to calculate the network output weights. This optimization scheme exploits intrinsic graph structures in order to describe geometric data relationships in the so-called ELM space. Kernel formulations of the approach operating in ELM spaces of arbitrary dimensions are also provided. It is shown that the application of the optimization scheme exploiting geometric data relationships in the original ELM space is equivalent to the application of the original S-ELM to a transformed ELM space. The experimental results show that the incorporation of geometric data relationships in S-ELM can lead to enhanced performance.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics, Aristotle University of Thessaloniki

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

Number of pages: 5

Pages: 192-196

Publication date: 1 Nov 2015

Peer-reviewed: Yes

#### **Publication information**

Journal: Pattern Recognition Letters

Volume: 65

ISSN (Print): 0167-8655

Ratings:

Scopus rating (2015): CiteScore 5.1 SJR 0.95 SNIP 2.002

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing

Keywords: Intrinsic graphs, Single-hidden layer neural networks, Sparse extreme learning machine

DOIs:

10.1016/j.patrec.2015.07.036

Source: Scopus

Source ID: 84940388000

Research output: Contribution to journal › Article › Scientific › peer-review

### **Coupled dictionaries for exemplar-based speech enhancement and automatic speech recognition**

Exemplar-based speech enhancement systems work by decomposing the noisy speech as a weighted sum of speech and noise exemplars stored in a dictionary and use the resulting speech and noise estimates to obtain a time-varying filter in the full-resolution frequency domain to enhance the noisy speech. To obtain the decomposition, exemplars sampled in lower dimensional spaces are preferred over the full-resolution frequency domain for their reduced computational complexity and the ability to better generalize to unseen cases. But the resulting filter may be sub-optimal as the mapping of the obtained speech and noise estimates to the full-resolution frequency domain yields a low-rank approximation. This paper proposes an efficient way to directly compute the full-resolution frequency estimates of speech and noise using coupled dictionaries: an input dictionary containing atoms from the desired exemplar space to obtain the decomposition and a coupled output dictionary containing exemplars from the full-resolution frequency domain. We also introduce modulation spectrogram features for the exemplar-based tasks using this approach. The proposed system was evaluated for various choices of input exemplars and yielded improved speech enhancement performances on the AURORA-2 and AURORA-4 databases. We further show that the proposed approach also results in improved word error rates (WERs) for the speech recognition tasks using HMM-GMM and deep-neural network (DNN) based systems.



### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Audio research group, Research Community on Data-to-Decision (D2D), Signal Processing Research Community (SPRC), Speech Processing Research Group, Electrical Engineering Department (ESAT), KU Leuven

Contributors: Baby, D., Virtanen, T., Gemmeke, J. F., Van hamme, H.

Number of pages: 12

Pages: 1788-1799

Publication date: 1 Nov 2015

Peer-reviewed: Yes

### Publication information

Journal: *Ieee-Acm transactions on audio speech and language processing*

Volume: 23

Issue number: 11

ISSN (Print): 2329-9290

Ratings:

Scopus rating (2015): CiteScore 1.6 SJR 1.13 SNIP 1.475

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering, Media Technology, Acoustics and Ultrasonics, Instrumentation, Linguistics and Language, Speech and Hearing

Keywords: Exemplar-based, Modulation envelope, Noise robust automatic speech recognition, Non-negative sparse coding

DOIs:

10.1109/TASLP.2015.2450491

Source: Scopus

Source ID: 84942609488

Research output: Contribution to journal › Article › Scientific › peer-review

### Model selection for linear classifiers using Bayesian error estimation

Regularized linear models are important classification methods for high dimensional problems, where regularized linear classifiers are often preferred due to their ability to avoid overfitting. The degree of freedom of the model is determined by a regularization parameter, which is typically selected using counting based approaches, such as K-fold cross-validation. For large data, this can be very time consuming, and, for small sample sizes, the accuracy of the model selection is limited by the large variance of CV error estimates. In this paper, we study the applicability of a recently proposed Bayesian error estimator for the selection of the best model along the regularization path. We also propose an extension of the estimator that allows model selection in multiclass cases and study its efficiency with L-1 regularized logistic regression and L-2 regularized linear support vector machine. The model selection by the new Bayesian error estimator is experimentally shown to improve the classification accuracy, especially in small sample-size situations, and is able to avoid the excess variability inherent to traditional cross-validation approaches. Moreover, the method has significantly smaller computational complexity than cross-validation. (C) 2015 Elsevier Ltd. All rights reserved.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Vision, Research Community on Data-to-Decision (D2D), Universidad Carlos III de Madrid

Contributors: Huttunen, H., Tohka, J.

Number of pages: 10

Pages: 3739-3748

Publication date: Nov 2015

Peer-reviewed: Yes

### Publication information

Journal: *Pattern Recognition*

Volume: 48

Issue number: 11

ISSN (Print): 0031-3203

Ratings:

Scopus rating (2015): CiteScore 8.6 SJR 1.579 SNIP 2.996

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing

Keywords: Logistic regression, Support vector machine, Regularization, Bayesian error estimator, Linear classifier, MULTINOMIAL LOGISTIC-REGRESSION, SUPPORT VECTOR MACHINES, CLASSIFICATION, PERFORMANCE, BOUNDS

DOIs:

10.1016/j.patcog.2015.05.005

### **Bibliographical note**

EXT="Tohka, Jussi"

Source: Scopus

Source ID: 84937812363

Research output: Contribution to journal > Article > Scientific > peer-review

### **Solutions to integrals involving the marcum Q-function and applications**

Novel analytic solutions are derived for integrals that involve the generalized Marcum Q -function, exponential functions and arbitrary powers. Simple closed-form expressions are also derived for specific cases of the generic integrals. The offered expressions are both convenient and versatile, which is particularly useful in applications relating to natural sciences and engineering, including wireless communications and signal processing. To this end, they are employed in the derivation of the average probability of detection in energy detection of unknown signals over multipath fading channels as well as of the channel capacity with fixed rate and channel inversion in the case of correlated multipath fading and switched diversity.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Department of Electrical and Computer Engineering, Khalifa University, Centre for Communication Systems Research, Department of Electronic Engineering, University of Surrey, Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki

Contributors: Sofotasios, P. C., Muhaidat, S., Karagiannidis, G. K., Sharif, B. S.

Number of pages: 5

Pages: 1752-1756

Publication date: 1 Oct 2015

Peer-reviewed: Yes

### **Publication information**

Journal: IEEE Signal Processing Letters

Volume: 22

Issue number: 10

ISSN (Print): 1070-9908

Ratings:

Scopus rating (2015): CiteScore 4.2 SJR 0.822 SNIP 1.798

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics

DOIs:

10.1109/LSP.2015.2432064

Source: Scopus

Source ID: 84930225545

Research output: Contribution to journal > Article > Scientific > peer-review

### **Adaptive Randomized Coordinate Descent for Sparse Systems: Lasso and Greedy Algorithms**

Coordinate descent (CD) is a simple optimization technique suited to low complexity requirements and also for solving large problems. In randomized version, CD was recently shown as very effective for solving least-squares (LS) and other optimization problems. We propose here an adaptive version of randomized coordinate descent (RCD) for finding sparse LS solutions, from which we derive two algorithms, one based on the lasso criterion, the other using a greedy technique. Both algorithms employ a novel way of adapting the probabilities for choosing the coordinates, based on a matching pursuit criterion. Another new feature is that, in the lasso algorithm, the penalty term values are built without knowing the noise level or using other prior information. The proposed algorithms use efficient computations and have a tunable trade-off between complexity and performance through the number of CD steps per time instant. Besides a general theoretical convergence analysis, we present simulations that show good practical behavior, comparable to or better than that of state of the art methods.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: SGN-SPAG, Signal Processing Research Community (SPRC)

Contributors: Onose, A., Dumitrescu, B.

Number of pages: 11  
Pages: 4091-4101  
Publication date: 1 Aug 2015  
Peer-reviewed: Yes

#### **Publication information**

Journal: IEEE Transactions on Signal Processing  
Volume: 63  
Issue number: 15  
ISSN (Print): 1053-587X  
Ratings:  
Scopus rating (2015): CiteScore 8 SJR 1.581 SNIP 2.687  
Original language: English  
ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing  
Keywords: Adaptive algorithms, coordinate descent, randomization, sparse filters  
DOIs:  
10.1109/TSP.2015.2436369  
Source: Scopus  
Source ID: 84934311735  
Research output: Contribution to journal > Article > Scientific > peer-review

#### **Adaptive sampling for compressed sensing based image compression**

The compressed sensing (CS) theory has been successfully applied to image compression in the past few years as most image signals are sparse in a certain domain. In this paper, we focus on how to improve the sampling efficiency for CS-based image compression by using our proposed adaptive sampling mechanism on the block-based CS (BCS), especially the reweighted one. To achieve this goal, two solutions are developed at the sampling side and reconstruction side, respectively. The proposed sampling mechanism allocates the CS-measurements to image blocks according to the statistical information of each block so as to sample the image more efficiently. A generic allocation algorithm is developed to help assign CS-measurements and several allocation factors derived in the transform domain are used to control the overall allocation in both solutions. Experimental results demonstrate that our adaptive sampling scheme offers a very significant quality improvement as compared with traditional non-adaptive ones.

#### **General information**

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Department of Signal Processing, Research group: Video, Research Community on Data-to-Decision (D2D), Institute of Image Processing, University of Electronic Science and Technology of China, Hong Kong University of Science and Technology  
Contributors: Zhu, S., Zeng, B., Gabbouj, M.  
Number of pages: 12  
Pages: 94-105  
Publication date: 1 Jul 2015  
Peer-reviewed: Yes

#### **Publication information**

Journal: Journal of Visual Communication and Image Representation  
Volume: 30  
ISSN (Print): 1047-3203  
Ratings:  
Scopus rating (2015): CiteScore 3.6 SJR 0.632 SNIP 1.525  
Original language: English  
ASJC Scopus subject areas: Electrical and Electronic Engineering, Media Technology, Computer Vision and Pattern Recognition, Signal Processing  
Keywords: Adaptive sampling, Block-based compressed sensing (BCS), Image coding, Image compression, Measurement allocation, Sampling efficiency, Sparsity Compressed sensing (CS)  
DOIs:  
10.1016/j.jvcir.2015.03.006  
Source: Scopus  
Source ID: 84926618362  
Research output: Contribution to journal > Article > Scientific > peer-review

#### **Actor Merging for Dataflow Process Networks**

Dataflow process networks provide a versatile model of computation for specifying signal processing applications in a platform independent fashion. This attractive feature of dataflow has lately been realized in dataflow programming tools that allow synthesizing the same application specification as both fixed hardware circuits and as software for

programmable processors. However, in practice, the specification granularity of the dataflow program remains an arbitrary choice of the designer. Dataflow specifications of the same application with equivalent I/O behaviour can range from a single dataflow actor to a very fine grained network composed of elementary processing operations. A very fine grained dataflow specification might result into a high performance implementation when synthesized as hardware, but might perform poorly when executed on a programmable processor. This article presents actor merging as one solution for this performance portability problem of dataflow programs. In contrast to previous work around actor merging, this article presents a methodology that can merge also dynamic dataflow actors. To support these claims, results of experiments on several processing platforms and application examples ranging from telecommunications to video compression are reported.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), Dept. of Computer Science and Engineering, Univ of Oulu, Abo Akad Univ, Abo Akademi University, Dept Phys, CRPP

Contributors: Boutellier, J., Ersfolk, J., Lilius, J., Mattavelli, M., Roquier, G., Silvén, O.

Number of pages: 13

Pages: 2496-2508

Publication date: 15 May 2015

Peer-reviewed: Yes

### Publication information

Journal: IEEE Transactions on Signal Processing

Volume: 63

Issue number: 10

Article number: 7055878

ISSN (Print): 1053-587X

Ratings:

Scopus rating (2015): CiteScore 8 SJR 1.581 SNIP 2.687

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Dataflow computing, design automation, signal processing

DOIs:

10.1109/TSP.2015.2411229

URLs:

<http://www.scopus.com/inward/record.url?scp=84928152213&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84928152213

Research output: Contribution to journal › Article › Scientific › peer-review

### Spectrum Sensing under RF Non-Linearities: Performance Analysis and DSP-Enhanced Receivers

Intermodulation products arise as a result of low noise amplifier (LNA) and mixer non-linearities in wideband receivers. In the presence of strong blockers, the intermodulation distortion can deteriorate the spectrum sensing performance by causing false alarms and degrading the detection probability. We theoretically analyze the impact of third-order non-linearities on the detection and false alarm probabilities for both energy detectors and cyclostationary detectors under front-end LNA non-linearities. We show that degradation of the detection performance due to nonlinearities of both energy and cyclostationary detection is strongly dependent on the modulation type of the blockers. We then propose two DSP-enhanced receiver architectures to compensate the impact of nonlinearities. The first approach is a post-processing technique which compensates for nonlinearities effect on the test statistic by adapting the sensing time and detection threshold. The second approach is a pre-processing method that compensates by correcting received samples prior to computing the test statistic. This approach is based on adaptively estimating the intermodulation distortion, weighting it by a scalar constant and subtracting it from the subband of interest. We propose a method to adaptively compute the optimal weighting coefficient and show that it depends on the power and modulation of the blockers. Our results show that the pre-processing sample-based compensation method is more effective and that clear dynamic range extension can be obtained by using intermodulation compensation without resorting to increasing the sensing time. We also study the impact of uncertainties about the knowledge or estimates for nonlinearity parameters.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Electrical Engineering Department, University of California, Los Angeles (UCLA), Qualcomm Research, Maxlinear

Contributors: Rebeiz, E., Hagh Ghadam, A. S., Valkama, M., Cabric, D.

Number of pages: 15

Pages: 1950-1964  
Publication date: 15 Apr 2015  
Peer-reviewed: Yes

#### Publication information

Journal: IEEE Transactions on Signal Processing  
Volume: 63  
Issue number: 8  
ISSN (Print): 1053-587X  
Ratings:

Scopus rating (2015): CiteScore 8 SJR 1.581 SNIP 2.687

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing

Keywords: Cognitive radios, cyclostationary detection, energy detection, intermodulation, nonlinear distortion, nonlinearity compensation, sensing receiver, wideband sensing

DOIs:

10.1109/TSP.2015.2401532

#### Bibliographical note

EXT="Hagh Ghadam, Ali Shahed"

Source: Scopus

Source ID: 84925070855

Research output: Contribution to journal › Article › Scientific › peer-review

#### Multiresolution analysis for compactly supported interpolating tensor product wavelets

We construct multidimensional interpolating tensor product multiresolution analyses (MRA's) of the function spaces  $C_0(\mathbb{R}^n, K)$ ,  $K = \mathbb{R}$  or  $K = \mathbb{C}$ , consisting of real or complex valued functions on  $\mathbb{R}^n$  vanishing at infinity and the function spaces  $C_u(\mathbb{R}^n, K)$  consisting of bounded and uniformly continuous functions on  $\mathbb{R}^n$ . We also construct an interpolating dual MRA for both of these spaces. The theory of the tensor products of Banach spaces is used. We generalize the Besov space norm equivalence from the one-dimensional case to our  $n$ -dimensional construction.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Physics

Contributors: Höynälänmaa, T.

Number of pages: 36

Publication date: 6 Mar 2015

Peer-reviewed: Yes

#### Publication information

Journal: International Journal of Wavelets Multiresolution and Information Processing

Volume: 13

Issue number: 2

Article number: 1550010

ISSN (Print): 0219-6913

Ratings:

Scopus rating (2015): CiteScore 1.1 SJR 0.319 SNIP 0.547

Original language: English

ASJC Scopus subject areas: Applied Mathematics, Information Systems, Signal Processing

Keywords: Besov space, injective tensor norm, Interpolating wavelets, multiresolution analysis, multivariate wavelets, projective tensor norm, tensor Product

DOIs:

10.1142/S0219691315500101

URLs:

<http://www.scopus.com/inward/record.url?scp=84928923864&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84928923864

Research output: Contribution to journal › Article › Scientific › peer-review

#### On the kernel Extreme Learning Machine classifier

In this paper, we discuss the connection of the kernel versions of the ELM classifier with infinite Single-hidden Layer Feedforward Neural networks and show that the original ELM kernel definition can be adopted for the calculation of the ELM kernel matrix for two of the most common activation functions, i.e., the RBF and the sigmoid functions. In addition,

we show that a low-rank decomposition of the kernel matrix defined on the input training data can be exploited in order to determine an appropriate ELM space for input data mapping. The ELM space determined from this process can be subsequently used for network training using the original ELM formulation. Experimental results denote that the adoption of the low-rank decomposition-based ELM space determination leads to enhanced performance, when compared to the standard choice, i.e., random input weights generation.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

Number of pages: 7

Pages: 11-17

Publication date: 1 Mar 2015

Peer-reviewed: Yes

#### Publication information

Journal: Pattern Recognition Letters

Volume: 54

ISSN (Print): 0167-8655

Ratings:

Scopus rating (2015): CiteScore 5.1 SJR 0.95 SNIP 2.002

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing

Keywords: Extreme learning machine, Infinite networks, Single-hidden layer networks

DOIs:

10.1016/j.patrec.2014.12.003

URLs:

<http://www.scopus.com/inward/record.url?scp=84920068822&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84920068822

Research output: Contribution to journal › Article › Scientific › peer-review

#### Image database TID2013: Peculiarities, results and perspectives

This paper describes a recently created image database, TID2013, intended for evaluation of full-reference visual quality assessment metrics. With respect to TID2008, the new database contains a larger number (3000) of test images obtained from 25 reference images, 24 types of distortions for each reference image, and 5 levels for each type of distortion. Motivations for introducing 7 new types of distortions and one additional level of distortions are given; examples of distorted images are presented. Mean opinion scores (MOS) for the new database have been collected by performing 985 subjective experiments with volunteers (observers) from five countries (Finland, France, Italy, Ukraine, and USA). The availability of MOS allows the use of the designed database as a fundamental tool for assessing the effectiveness of visual quality. Furthermore, existing visual quality metrics have been tested with the proposed database and the collected results have been analyzed using rank order correlation coefficients between MOS and considered metrics. These correlation indices have been obtained both considering the full set of distorted images and specific image subsets, for highlighting advantages and drawbacks of existing, state of the art, quality metrics. Approaches to thorough performance analysis for a given metric are presented to detect practical situations or distortion types for which this metric is not adequate enough to human perception. The created image database and the collected MOS values are freely available for downloading and utilization for scientific purposes.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Computational Imaging-CI, Research group: Algebraic and Algorithmic Methods in Signal Processing AAMSP, Signal Processing Research Community (SPRC), National Aerospace University, Dept of Transmitters, Receivers and Signal Processing, University of Rennes 1 - IETR, Media Communications Lab, USC Viterbi School of Engineering

Contributors: Ponomarenko, N., Jin, L., Ieremeiev, O., Lukin, V., Egiazarian, K., Astola, J., Vozel, B., Chehdi, K., Carli, M., Battisti, F., Jay Kuo, C. C.

Number of pages: 21

Pages: 57-77

Publication date: 1 Jan 2015

Peer-reviewed: Yes

#### Publication information

Journal: Signal Processing: Image Communication

Volume: 30

ISSN (Print): 0923-5965

Ratings:

Scopus rating (2015): CiteScore 4 SJR 0.532 SNIP 1.413

Original language: English

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Signal Processing, Software, Electrical and Electronic Engineering

Keywords: Image denoising, Image lossy compression, Image visual quality metrics

DOIs:

10.1016/j.image.2014.10.009

URLs:

<http://www.scopus.com/inward/record.url?scp=84919839405&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84919839405

Research output: Contribution to journal > Article > Scientific > peer-review

### **Analytical model in discrete time for cross-layer video communication over LTE**

Since video traffic is resource intensive, it is a challenging issue to stream video over low bandwidth networks, whereas video communication over LTE becomes an open research topic nowadays due to LTE's high throughput capabilities. Indeed, video transmission requires low delay, and wireless channel is time-varying, which result in a scenario when a layer-separated design is replaced by a Cross-Layer Adaptation (CLA) principle. In this paper an efficient analytical model that evaluates the behavior of the downlink LTE channel with CLA is presented. To the best of our knowledge, this is the first time an analytical model using CLA principle has been devised that covers both the transmission process from the eNB to the User Equipment (UE) at the first phase and video decoding process at the UE at the second phase. In order to ensure the cross-layer adaptation in the model, the arrival rate varies based on the received video request, whereas the service probability changes according to the channel quality indicator sent from the UE. In the experimental part the analysis of the main performance measures found from the stationary distribution is conducted.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Video, Research Community on Data-to-Decision (D2D), Department of Telecommunication Systems, Peoples' Friendship University of Russia

Contributors: Efimushkina, T., Gabbouj, M., Samuylov, K.

Number of pages: 13

Pages: 345-357

Publication date: 2015

Peer-reviewed: Yes

#### **Publication information**

Journal: Automatic Control and Computer Sciences

Volume: 48

Issue number: 6

ISSN (Print): 0146-4116

Ratings:

Scopus rating (2015): CiteScore 0.4 SJR 0.184 SNIP 0.561

Original language: English

ASJC Scopus subject areas: Signal Processing, Software, Control and Systems Engineering

Keywords: cross-layer adaptation, DASH, downlink, LTE, OFDMA, queuing system, stationary distribution

DOIs:

10.3103/S0146411614060029

Source: Scopus

Source ID: 84920176216

Research output: Contribution to journal > Article > Scientific > peer-review

### **Digital correction of frequency response mismatches in 2-channel time-interleaved ADCs using adaptive I/Q signal processing**

A novel adaptive compensation architecture for the frequency response mismatch of 2-channel time-interleaved ADC (TI-ADC) is proposed for developing high-performance self-adaptive systems. The proposed approach overcomes the existing methods in the sense that the TI-ADC mismatch identification can be performed without allocating a region where only the TI-ADC mismatch spurs are present. This is accomplished via mapping the TI-ADC problem into an I/Q mismatch problem which allows deploying complex statistical signal processing. As proof of concept, the compensation architecture is demonstrated and tested on a 16-bit TI-ADC measured hardware data.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Wireless Communications and Positioning (WICO), Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Airbus Defense and Space

Contributors: Singh, S., Valkama, M., Epp, M., Anttila, L., Schlecker, W., Ingber, E.

Number of pages: 13

Pages: 543-555

Publication date: 2015

Peer-reviewed: Yes

### Publication information

Journal: Analog Integrated Circuits and Signal Processing

Volume: 82

Issue number: 3

ISSN (Print): 0925-1030

Ratings:

Scopus rating (2015): CiteScore 1.2 SJR 0.197 SNIP 0.42

Original language: English

ASJC Scopus subject areas: Surfaces, Coatings and Films, Hardware and Architecture, Signal Processing

Keywords: Circularity, Complex I/Q signal processing, Digitally assisted analog (DASA), Frequency response mismatch identification, Time-interleaved ADC

DOIs:

10.1007/s10470-014-0476-9

Source: Scopus

Source ID: 84925535772

Research output: [Contribution to journal](#) > [Article](#) > [Scientific](#) > [peer-review](#)

### Subjective evaluation of Super Multi-View compressed contents on high-end light-field 3D displays

Super Multi-View (SMV) video content is composed of tens or hundreds of views that provide a light-field representation of a scene. This representation allows a glass-free visualization and eliminates many causes of discomfort existing in current available 3D video technologies. Efficient video compression of SMV content is a key factor for enabling future 3D video services. This paper first compares several coding configurations for SMV content and several inter-view prediction structures are also tested and compared. The experiments mainly suggest that large differences in coding efficiency can be observed from one configuration to another. Several ratios for the number of coded and synthesized views are compared, both objectively and subjectively. It is reported that view synthesis significantly affects the coding scheme. The amount of views to skip highly depends on the sequence and on the quality of the associated depth maps. Reported ranges of bitrates required to obtain a good quality for the tested SMV content are realistic and coherent with future 4. K/8. K needs. The reliability of the PSNR metric for SMV content is also studied. Objective and subjective results show that PSNR is able to reflect increase or decrease in subjective quality even in the presence of synthesized views. However, depending on the ratio of coded and synthesized views, the order of magnitude of the effective quality variation is biased by PSNR. Results indicate that PSNR is less tolerant to view synthesis artifacts than human viewers. Finally, preliminary observations are initiated. First, the light-field conversion step does not seem to alter the objective results for compression. Secondly, the motion parallax does not seem to be impacted by specific compression artifacts. The perception of the motion parallax is only altered by variations of the typical compression artifacts along the viewing angle, in cases where the subjective image quality is already low. To the best of our knowledge, this paper is the first to carry out subjective experiments and to report results of SMV compression for light-field 3D displays. It provides first results showing that improvement of compression efficiency is required, as well as depth estimation and view synthesis algorithms improvement, but that the use of SMV appears realistic according to next generation compression technology requirements.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Orange Labs, Holografika Kft., Pámany Peter Katolikus Egyetem

Contributors: Dricot, A., Jung, J., Cagnazzo, M., Pesquet, B., Dufaux, F., Kovács, P., Adhikarla, V. K.

Pages: 369–385

Publication date: 2015

Peer-reviewed: Yes

### Publication information

Journal: Signal Processing: Image Communication

Volume: 39

Issue number: Part B

ISSN (Print): 0923-5965



Ratings:

Scopus rating (2015): CiteScore 4 SJR 0.532 SNIP 1.413

Original language: English

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Signal Processing, Software, Electrical and Electronic Engineering

Keywords: 3D, Light-field, Subjective evaluation, Super Multi-View, Video coding, Video compression

DOIs:

10.1016/j.image.2015.04.012

Source: Scopus

Source ID: 84947865722

Research output: Contribution to journal > Article > Scientific > peer-review

### **Non-negative tensor factorization models for Bayesian audio processing**

We provide an overview of matrix and tensor factorization methods from a Bayesian perspective, giving emphasis on both the inference methods and modeling techniques. Factorization based models and their many extensions such as tensor factorizations have proved useful in a broad range of applications, supporting a practical and computationally tractable framework for modeling. Especially in audio processing, tensor models help in a unified manner the use of prior knowledge about signals, the data generation processes as well as available data from different modalities. After a general review of tensor models, we describe the general statistical framework, give examples of several audio applications and describe modeling strategies for key problems such as deconvolution, source separation, and transcription.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Signal Processing, Research group: Audio research group, Research Community on Data-to-Decision (D2D), Signal Processing Research Community (SPRC), Bogazici Universitesi

Contributors: Şimşekli, U., Virtanen, T., Cemgil, A. T.

Pages: 178–191

Publication date: 2015

Peer-reviewed: Yes

#### **Publication information**

Journal: Digital Signal Processing

Volume: 47

ISSN (Print): 1051-2004

Ratings:

Scopus rating (2015): CiteScore 3.3 SJR 0.566 SNIP 1.368

Original language: English

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Bayesian audio modeling, Bayesian inference, Coupled factorization, Nonnegative matrix and tensor factorization

DOIs:

10.1016/j.dsp.2015.03.011

Source: Scopus

Source ID: 84948075383

Research output: Contribution to journal > Article > Scientific > peer-review

### **Smart home gateway system over Bluetooth low energy with wireless energy transfer capability**

As billions of sensors and smart meters connect to the Internet of Things (IoT), current wireless technologies are taking decisive steps to ensure their sustainable operation. One popular IoT scenario features a smart home service gateway, which becomes the central point of user's home environment facilitating a multitude of tasks. Given that most IoT devices connected to residential gateway are small-scale and battery-powered, the key challenge is to extend their lifetime without recharging/replacing batteries. To this end, a novel radio technology named Bluetooth low energy (BLE) has recently been completed to enable energy-efficient data transfer. Another inspiring innovation is the capability of sensors to harvest wireless energy in their local environment. In this work, we envision a scenario where many in-home sensors are communicating with a smart gateway over the BLE protocol, while at the same time harvesting RF energy transmitted from the gateway wirelessly via a dedicated radio interface. We thoroughly investigate performance limitations of such wireless energy transfer interface (WETI) with dynamic analytical model and with important practical considerations. Our methodology delivers the upper bound on WETI operation coupled with BLE-based communication, which characterizes ultimate system performance over the class of practical radio and energy resource management algorithms.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Wireless Communications and Positioning (WICO), International Institute for Advanced Aerospace Technologies of St. Petersburg State University of Aerospace Instrumentation  
Contributors: Galinina, O., Mikhaylov, K., Andreev, S., Turlikov, A., Koucheryavy, Y.  
Publication date: 2015  
Peer-reviewed: Yes

#### **Publication information**

Journal: Eurasip Journal on Wireless Communications and Networking

Volume: 2015

Issue number: 1

Article number: 178

ISSN (Print): 1687-1472

Ratings:

Scopus rating (2015): CiteScore 2.7 SJR 0.362 SNIP 1.138

Original language: English

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Computer Science Applications

Keywords: Bluetooth low energy, Internet of Things, Sensors, Smart home gateway, Wireless energy transfer

DOIs:

10.1186/s13638-015-0393-3

Source: Scopus

Source ID: 84938840129

Research output: Contribution to journal › Article › Scientific › peer-review

#### **Class-Specific Reference Discriminant Analysis With Application in Human Behavior Analysis**

In this paper, a novel nonlinear subspace learning technique for class-specific data representation is proposed. A novel data representation is obtained by applying nonlinear class-specific data projection to a discriminant feature space, where the data belonging to the class under consideration are enforced to be close to their class representation, while the data belonging to the remaining classes are enforced to be as far as possible from it. A class is represented by an optimized class vector, enhancing class discrimination in the resulting feature space. An iterative optimization scheme is proposed to this end, where both the optimal nonlinear data projection and the optimal class representation are determined in each optimization step. The proposed approach is tested on three problems relating to human behavior analysis: Face recognition, facial expression recognition, and human action recognition. Experimental results denote the effectiveness of the proposed approach, since the proposed class-specific reference discriminant analysis outperforms kernel discriminant analysis, kernel spectral regression, and class-specific kernel discriminant analysis, as well as support vector machine-based classification, in most cases.

#### **General information**

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MoE publication type: A1 Journal article-refereed

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

Pages: 315-326

Publication date: 25 Dec 2014

Peer-reviewed: Yes

#### **Publication information**

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Original language: English

ASJC Scopus subject areas: Artificial Intelligence, Signal Processing, Human Factors and Ergonomics, Computer Networks and Communications, Computer Science Applications, Human-Computer Interaction, Control and Systems Engineering

DOIs:

10.1109/THMS.2014.2379274

Research output: Contribution to journal › Article › Scientific › peer-review

### **Kernel reference discriminant analysis**

Linear Discriminant Analysis (LDA) and its nonlinear version Kernel Discriminant Analysis (KDA) are well-known and widely used techniques for supervised feature extraction and dimensionality reduction. They determine an optimal discriminant space for (non)linear data projection based on certain assumptions, e.g. on using normal distributions (either on the input or in the kernel space) for each class and employing class representation by the corresponding class mean vectors. However, there might be other vectors that can be used for classes representation, in order to increase class discrimination in the resulted feature space. In this paper, we propose an optimization scheme aiming at the optimal class representation, in terms of Fisher ratio maximization, for nonlinear data projection. Compared to the standard approach, the proposed optimization scheme increases class discrimination in the reduced-dimensionality feature space and achieves higher classification rates in publicly available data sets.

### **General information**

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MoE publication type: A1 Journal article-refereed

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

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Publication date: 1 Nov 2014

Peer-reviewed: Yes

### **Publication information**

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Scopus rating (2014): CiteScore 4.3 SJR 0.73 SNIP 2.131

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing

Keywords: Kernel Discriminant Analysis, Kernel Spectral Regression, Optimized class representation

DOIs:

10.1016/j.patrec.2014.06.013

Source: Scopus

Source ID: 84904957982

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### **Discriminant Bag of Words based representation for human action recognition**

In this paper we propose a novel framework for human action recognition based on Bag of Words (BoWs) action representation, that unifies discriminative codebook generation and discriminant subspace learning. The proposed framework is able to, naturally, incorporate several (linear or non-linear) discrimination criteria for discriminant BoWs-based action representation. An iterative optimization scheme is proposed for sequential discriminant BoWs-based action representation and codebook adaptation based on action discrimination in a reduced dimensionality feature space where action classes are better discriminated. Experiments on five publicly available data sets aiming at different application scenarios demonstrate that the proposed unified approach increases the codebook discriminative ability providing enhanced action classification performance.

### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

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Volume: 49

ISSN (Print): 0167-8655

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Scopus rating (2014): CiteScore 4.3 SJR 0.73 SNIP 2.131

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing  
Keywords: Bag of Words, Codebook learning, Discriminant learning  
DOIs:  
10.1016/j.patrec.2014.07.011  
Source: Scopus  
Source ID: 84907347636  
Research output: Contribution to journal › Article › Scientific › peer-review

### **Implementation of a high-throughput low-latency polyphase channelizer on GPUs Design and Architectures for Signal and Image Processing 2008**

A channelizer is used to separate users or channels in communication systems. A polyphase channelizer is a type of channelizer that uses polyphase filtering to filter, downsample, and downconvert simultaneously. With graphics processing unit (GPU) technology, we propose a novel GPU-based polyphase channelizer architecture that delivers high throughput. This architecture has advantages of providing reduced complexity and optimized parallel processing of many channels, while being configurable via software. This makes our approach and implementation particularly attractive for using GPUs as DSP accelerators for communication systems.

#### **General information**

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MoE publication type: A1 Journal article-refereed  
Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering  
Contributors: Kim, S. C., Bhattacharyya, S. S.  
Publication date: 2014  
Peer-reviewed: Yes

#### **Publication information**

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Volume: 2014  
Issue number: 1  
ISSN (Print): 1687-6172  
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Scopus rating (2014): CiteScore 2.2 SJR 0.286 SNIP 0.937  
Original language: English  
ASJC Scopus subject areas: Signal Processing, Hardware and Architecture, Electrical and Electronic Engineering  
Keywords: DSP accelerator, GPU front-end receiver, GPU-based radio, Polyphase channelizer, Polyphase filter  
DOIs:  
10.1186/1687-6180-2014-141  
URLs:  
<http://www.scopus.com/inward/record.url?scp=84907545943&partnerID=8YFLogxK> (Link to publication in Scopus)  
Source: Scopus  
Source ID: 84907545943  
Research output: Contribution to journal › Article › Scientific › peer-review

### **Automated design of networks of transport-triggered architecture processors using dynamic dataflow programs**

Modern embedded systems show a clear trend towards the use of Multiprocessor System-on-Chip (MPSoC) architectures in order to handle the performance and power consumption constraints. However, the design and validation of dedicated MPSoCs is an extremely hard and expensive task due to their complexity. Thus, the development of automated design processes is of highest importance to satisfy the time-to-market pressure of embedded systems. This paper proposes an automated co-design flow based on the high-level language-based approach of the Reconfigurable Video Coding framework. The designer provides the application description in the RVC-CAL dataflow language, after which the presented co-design flow automatically generates a network of heterogeneous processors that can be synthesized on FPGA chips. The synthesized processors are Very Long Instruction Word-style processors. Such a methodology permits the rapid design of a many-core signal processing system which can take advantage of all levels of parallelism. The toolchain functionality has been demonstrated by synthesizing an MPEG-4 Simple Profile video decoder to two different FPGA boards. The decoder is realized into 18 processors that decode QCIF resolution video at 45 frames per second on a 50 MHz FPGA clock frequency. The results show that the given application can take advantage of every level of parallelism.

#### **General information**

Publication status: Published  
MoE publication type: A1 Journal article-refereed  
Organisations: Signal Processing Research Community (SPRC), Universite de Rennes, CSE Department, Univ of Oulu, UBL

Contributors: Yviquel, H., Boutellier, J., Raulet, M., Casseau, E.  
Number of pages: 8  
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Publication date: Nov 2013  
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#### Publication information

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ISSN (Print): 0923-5965  
Ratings:

Scopus rating (2013): CiteScore 3.2 SJR 0.407 SNIP 1.301

Original language: English

ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Electrical and Electronic Engineering

Keywords: Co-design, Dataflow programming, Multi-Processor System-on-Chip (MPSoC), Reconfigurable Video Coding (RVC), Transport-Trigger Architecture (TTA)

DOIs:

10.1016/j.image.2013.08.013

URLs:

<http://www.scopus.com/inward/record.url?scp=84888203042&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84888203042

Research output: Contribution to journal › Article › Scientific › peer-review

#### Towards generic embedded multiprocessing for RVC-CAL dataflow programs

Dataflow languages enable describing signal processing applications in a platform independent fashion, which makes them attractive in today's multiprocessing era. RVC-CAL is a dynamic dataflow language that enables describing complex data-dependent programs such as video decoders. To this date, design automation toolchains for RVC-CAL have enabled creating workstation software, dedicated hardware and embedded application specific multiprocessor implementations out of RVC-CAL programs. However, no solution has been presented for executing RVC-CAL applications on generic embedded multiprocessing platforms. This paper presents a dataflow-based multiprocessor communication model, an architecture prototype that uses it and an automated toolchain for instantiating such a platform and the software for it. The complexity of the platform increases linearly as the number of processors is increased. The experiments in this paper use several instances of the proposed platform, with different numbers of processors. An MPEG-4 video decoder is mapped to the platform and executed on it. Benchmarks are performed on an FPGA board.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), Dept. of Computer Science and Engineering, Univ of Oulu

Contributors: Boutellier, J., Silvén, O.

Number of pages: 6

Pages: 137-142

Publication date: Nov 2013

Peer-reviewed: Yes

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Journal: Journal of Signal Processing Systems  
Volume: 73  
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ISSN (Print): 1939-8018  
Ratings:

Scopus rating (2013): CiteScore 2.1 SJR 0.254 SNIP 0.866

Original language: English

ASJC Scopus subject areas: Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science, Control and Systems Engineering, Modelling and Simulation

Keywords: Data flow computing, Design automation, Multiprocessor interconnection

DOIs:

10.1007/s11265-013-0737-3

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Source: Scopus

Source ID: 84881476500

Research output: Contribution to journal › Article › Scientific › peer-review

### **Passive wireless antenna sensor for strain and crack sensing - Electromagnetic modeling, simulation, and testing**

This research investigates a passive wireless antenna sensor designed for strain and crack sensing. When the antenna experiences deformation, the antenna shape changes, causing a shift in the electromagnetic resonance frequency of the antenna. A radio frequency identification (RFID) chip is adopted for antenna signal modulation, so that a wireless reader can easily distinguish the backscattered sensor signal from unwanted environmental reflections. The RFID chip captures its operating power from an interrogation electromagnetic wave emitted by the reader, which allows the antenna sensor to be passive (battery-free). This paper first reports the latest simulation results on radiation patterns, surface current density, and electromagnetic field distribution. The simulation results are followed with experimental results on the strain and crack sensing performance of the antenna sensor. Tensile tests show that the wireless antenna sensor can detect small strain changes lower than 20  $\mu\epsilon$ , and can perform well at large strains higher than 10 000  $\mu\epsilon$ . With a high-gain reader antenna, the wireless interrogation distance can be increased up to 2.1 m. Furthermore, an array of antenna sensors is capable of measuring the strain distribution in close proximity. During emulated crack and fatigue crack tests, the antenna sensor is able to detect the growth of a small crack.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Sensing Systems for Wireless Medicine (MediSense), Georgia Institute of Technology, Georgia Institute of Technology, School of Electrical and Computer Engineering, Virginia Tech

Contributors: Yi, X., Cho, C., Cooper, J., Wang, Y., Tentzeris, M. M., Leon, R. T.

Publication date: Aug 2013

Peer-reviewed: Yes

#### **Publication information**

Journal: Smart Materials and Structures

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Issue number: 8

Article number: 085009

ISSN (Print): 0964-1726

Ratings:

Scopus rating (2013): CiteScore 4.4 SJR 1.006 SNIP 1.93

Original language: English

ASJC Scopus subject areas: Signal Processing, Atomic and Molecular Physics, and Optics, Civil and Structural Engineering, Materials Science(all), Condensed Matter Physics, Mechanics of Materials, Electrical and Electronic Engineering

DOIs:

10.1088/0964-1726/22/8/085009

URLs:

<http://www.scopus.com/inward/record.url?scp=84881172175&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84881172175

Research output: Contribution to journal › Article › Scientific › peer-review

### **Multi-view action recognition based on action volumes, fuzzy distances and cluster discriminant analysis**

In this paper, we present a view-independent action recognition method exploiting a low computational-cost volumetric action representation. Binary images depicting the human body during action execution are accumulated in order to produce the so-called action volumes. A novel time-invariant action representation is obtained by exploiting the circular shift invariance property of the magnitudes of the Discrete Fourier Transform coefficients. The similarity of an action volume with representative action volumes is exploited in order to map it to a lower-dimensional feature space that preserves the action class properties. Discriminant learning is, subsequently, employed for further dimensionality reduction and action class discrimination. By using such an action representation, the proposed approach performs fast action recognition. By combining action recognition results coming from different view angles, high recognition rates are obtained. The proposed method is extended to interaction recognition, i.e., to human action recognition involving two persons. The proposed approach is evaluated on a publicly available action recognition database using experimental settings simulating situations that may appear in real-life applications, as well as on a new nutrition support action recognition database.

#### **General information**

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Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

Number of pages: 13

Pages: 1445-1457

Publication date: Jun 2013

Peer-reviewed: Yes

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ISSN (Print): 0165-1684

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Scopus rating (2013): CiteScore 5.1 SJR 0.909 SNIP 2.244

Original language: English

ASJC Scopus subject areas: Electrical and Electronic Engineering, Control and Systems Engineering, Software, Signal Processing, Computer Vision and Pattern Recognition

Keywords: Action recognition, Action volumes, Cluster discriminant analysis, Fuzzy vector quantization

DOIs:

10.1016/j.sigpro.2012.08.015

Source: Scopus

Source ID: 84875267100

Research output: Contribution to journal › Article › Scientific › peer-review

#### Integration of dataflow-based heterogeneous multiprocessor scheduling techniques in GNU radio

As the variety of off-the-shelf processors expands, traditional implementation methods of systems for digital signal processing and communication are no longer adequate to achieve design objectives in a timely manner. There is a necessity for designers to easily track the changes in computing platforms, and apply them efficiently while reusing legacy code and optimized libraries that target specialized features in single processing units. In this context, we propose an integration workflow to schedule and implement Software Defined Radio (SDR) protocols that are developed using the GNU Radio environment on heterogeneous multiprocessor platforms. We show how to utilize Single Instruction Multiple Data (SIMD) units provided in Graphics Processing Units (GPUs) along with vector accelerators implemented in General Purpose Processors (GPPs). We augment a popular SDR framework (i.e, GNU Radio) with a library that seamlessly allows offloading of algorithm kernels mapped to the GPU without changing the original protocol description. Experimental results show how our approach can be used to efficiently explore design spaces for SDR system implementation, and examine the overhead of the integrated backend (software component) library.

#### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering, Virginia Tech, Laboratory for Telecommunications Sciences

Contributors: Zaki, G. F., Plishker, W., Bhattacharyya, S. S., Clancy, C., Kuykendall, J.

Number of pages: 15

Pages: 177-191

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#### Publication information

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Scopus rating (2013): CiteScore 2.1 SJR 0.254 SNIP 0.866

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Design methodology, GNU Radio, Graphic processor unit, Multiprocessor scheduling, Software defined radio

DOIs:

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Source: Scopus

Source ID: 84892800816

Research output: Contribution to journal › Article › Scientific › peer-review

### **Dynamic action recognition based on dynemes and Extreme Learning Machine**

In this paper, we propose a novel method that performs dynamic action classification by exploiting the effectiveness of the Extreme Learning Machine (ELM) algorithm for single hidden layer feedforward neural networks training. It involves data grouping and ELM based data projection in multiple levels. Given a test action instance, a neural network is trained by using labeled action instances forming the groups that reside to the test sample's neighborhood. The action instances involved in this procedure are, subsequently, mapped to a new feature space, determined by the trained network outputs. This procedure is performed multiple times, which are determined by the test action instance at hand, until only a single class is retained. Experimental results denote the effectiveness of the dynamic classification approach, compared to the static one, as well as the effectiveness of the ELM in the proposed dynamic classification setting.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

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Scopus rating (2013): CiteScore 4.8 SJR 0.768 SNIP 2.474

Original language: English

ASJC Scopus subject areas: Software, Artificial Intelligence, Computer Vision and Pattern Recognition, Signal Processing

Keywords: Activity recognition, Dynamic classification, Extreme Learning Machine, Fuzzy vector quantization

DOIs:

10.1016/j.patrec.2012.10.019

Source: Scopus

Source ID: 84885069818

Research output: Contribution to journal › Article › Scientific › peer-review

### **Automatic hierarchical discovery of quasi-static schedules of RVC-CAL dataflow programs**

RVC-CAL is an actor-based dataflow language that enables concurrent, modular and portable description of signal processing algorithms. RVC-CAL programs can be compiled to implementation languages such as C/C++ and VHDL for producing software or hardware implementations. This paper presents a methodology for automatic discovery of piecewise-deterministic (quasi-static) execution schedules for RVC-CAL program software implementations. Quasi-static scheduling moves computational burden from the implementable run-time system to design-time compilation and thus enables making signal processing systems more efficient. The presented methodology divides the RVC-CAL program into segments and hierarchically detects quasi-static behavior from each segment: first at the level of actors and later at the level of the whole segment. Finally, a code generator creates a quasi-statically scheduled version of the program. The impact of segment based quasi-static scheduling is demonstrated by applying the methodology to several RVC-CAL programs that execute up to 58 % faster after applying the presented methodology.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), Dept. of Computer Science and Engineering, Univ of Oulu, UBL

Contributors: Boutellier, J., Raulet, M., Silvén, O.

Number of pages: 6

Pages: 35-40

Publication date: 2013

Peer-reviewed: Yes



### Publication information

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Scopus rating (2013): CiteScore 2.1 SJR 0.254 SNIP 0.866

Original language: English

ASJC Scopus subject areas: Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science, Control and Systems Engineering, Modelling and Simulation

Keywords: Dataflow analysis, Scheduling, Signal processing

DOIs:

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<http://www.scopus.com/inward/record.url?scp=84873689972&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84873689972

Research output: Contribution to journal > Article > Scientific > peer-review

### Parameterized scheduling of topological patterns in signal processing dataflow graphs

In recent work, a graphical modeling construct called "topological patterns" has been shown to enable concise representation and direct analysis of repetitive dataflow graph sub-structures in the context of design methods and tools for digital signal processing systems (Sane et al. 2010). In this paper, we present a formal design method for specifying topological patterns and deriving parameterized schedules from such patterns based on a novel schedule model called the scalable schedule tree. The approach represents an important class of parameterized schedule structures in a form that is intuitive for representation and efficient for code generation. Through application case studies involving image processing and wireless communications, we demonstrate our methods for topological pattern representation, scalable schedule tree derivation, and associated dataflow graph code generation.

### General information

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Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering

Contributors: Wang, L. H., Shen, C. C., Wu, S., Bhattacharyya, S. S.

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Peer-reviewed: Yes

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Scopus rating (2013): CiteScore 2.1 SJR 0.254 SNIP 0.866

Original language: English

ASJC Scopus subject areas: Hardware and Architecture, Information Systems, Signal Processing, Theoretical Computer Science, Control and Systems Engineering, Modelling and Simulation

Keywords: Dataflow, Image registration, Scheduling, Software tools, Turbo decoder

DOIs:

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Source: Scopus

Source ID: 84879696501

Research output: Contribution to journal > Article > Scientific > peer-review

### Design and synthesis for multimedia systems using the targeted dataflow interchange format

Development of multimedia systems that can be targeted to different platforms is challenging due to the need for rigorous integration between high-level abstract modeling, and low-level synthesis and optimization. In this paper, a new dataflow-based design tool called the targeted dataflow interchange format is introduced for retargetable design, analysis, and implementation of embedded software for multimedia systems. Our approach provides novel capabilities, based on

principles of task-level dataflow analysis, for exploring and optimizing interactions across design components; object-oriented data structures for encapsulating contextual information for components; a novel model for representing parameterized schedules that are derived from repetitive graph structures; and automated code generation for programming interfaces and low-level customizations that are geared toward high-performance embedded-processing architectures. We demonstrate our design tool for cross-platform application design, parameterized schedule representation, and associated dataflow graph-code generation using a case study centered around an image registration application.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), University of Maryland, SAIC, New Jersey Institute of Technology, Department of Electrical and Computer Engineering

Contributors: Shen, C. C., Wu, S., Sane, N., Wu, H. H., Plishker, W., Bhattacharyya, S. S.

Number of pages: 11

Pages: 630-640

Publication date: 2012

Peer-reviewed: Yes

### Publication information

Journal: IEEE Transactions on Multimedia

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Article number: 6172244

ISSN (Print): 1520-9210

Ratings:

Scopus rating (2012): CiteScore 5.8 SJR 0.815 SNIP 2.573

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Computer Science Applications, Electrical and Electronic Engineering

Keywords: Dataflow graphs, design tools, embedded signal processing, scheduling, software synthesis

DOIs:

10.1109/TMM.2012.2191397

URLs:

<http://www.scopus.com/inward/record.url?scp=84861152678&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84861152678

Research output: [Contribution to journal](#) › [Article](#) › [Scientific](#) › [peer-review](#)

### Mapping parameterized cyclo-static dataflow graphs onto configurable hardware

In recent years, parameterized dataflow has evolved as a useful framework for modeling synchronous and cyclo-static graphs in which arbitrary parameters can be changed dynamically. Parameterized dataflow has proven to have significant expressive power for managing dynamics of DSP applications in important ways. However, efficient hardware synthesis techniques for parameterized dataflow representations are lacking. This paper addresses this void; specifically, the paper investigates efficient field programmable gate array (FPGA)-based implementation of parameterized cyclo-static dataflow (PCSDF) graphs. We develop a scheduling technique for throughput-constrained minimization of dataflow buffering requirements when mapping PCSDF representations of DSP applications onto FPGAs. The proposed scheduling technique is integrated with an existing formal schedule model, called the generalized schedule tree, to reduce schedule cost. To demonstrate our new, hardware-oriented PCSDF scheduling technique, we have designed a real-time base station emulator prototype based on a subset of long-term evolution (LTE), which is a key cellular standard.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), National Instruments, University of Maryland, Department of Electrical and Computer Engineering

Contributors: Kee, H., Shen, C. C., Bhattacharyya, S. S., Wong, I., Rao, Y., Kornerup, J.

Number of pages: 17

Pages: 285-301

Publication date: 2012

Peer-reviewed: Yes

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Issue number: 3  
ISSN (Print): 1939-8018  
Ratings:

Scopus rating (2012): CiteScore 2.1 SJR 0.269 SNIP 0.879

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: 4G communication systems, Dataflow modeling, FPGA implementation, Parameterized dataflow, Scheduling  
DOIs:

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URLs:

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Source: Scopus

Source ID: 84888881360

Research output: Contribution to journal › Article › Scientific › peer-review

### Overview of the MPEG reconfigurable video coding framework

Video coding technology in the last 20 years has evolved producing a variety of different and complex algorithms and coding standards. So far the specification of such standards, and of the algorithms that build them, has been done case by case providing monolithic textual and reference software specifications in different forms and programming languages. However, very little attention has been given to provide a specification formalism that explicitly presents common components between standards, and the incremental modifications of such monolithic standards. The MPEG Reconfigurable Video Coding (RVC) framework is a new ISO standard currently under its final stage of standardization, aiming at providing video codec specifications at the level of library components instead of monolithic algorithms. The new concept is to be able to specify a decoder of an existing standard or a completely new configuration that may better satisfy application-specific constraints by selecting standard components from a library of standard coding algorithms. The possibility of dynamic configuration and reconfiguration of codecs also requires new methodologies and new tools for describing the new bitstream syntaxes and the parsers of such new codecs. The RVC framework is based on the usage of a new actor/ dataflow oriented language called CAL for the specification of the standard library and instantiation of the RVC decoder model. This language has been specifically designed for modeling complex signal processing systems. CAL dataflow models expose the intrinsic concurrency of the algorithms by employing the notions of actor programming and dataflow. The paper gives an overview of the concepts and technologies building the standard RVC framework and the non standard tools supporting the RVC model from the instantiation and simulation of the CAL model to software and/or hardware code synthesis.

### General information

Publication status: Published

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Organisations: Signal Processing Research Community (SPRC), Department of Electrical and Computer Engineering, University of Maryland, Ericsson Research, Xilinx Research Labs, CRPP, UBL

Contributors: Bhattacharyya, S. S., Eker, J., Janneck, J. W., Lucarz, C., Mattavelli, M., Raulet, M.

Number of pages: 13

Pages: 251-263

Publication date: May 2011

Peer-reviewed: Yes

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ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: CAL actor language, Code synthesis, Dataflow programming, Reconfigurable Video Coding

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Source ID: 79954574143

Research output: Contribution to journal › Article › Scientific › peer-review

### **Quasi-static scheduling of CAL actor networks for reconfigurable video coding**

The upcoming Reconfigurable Video Coding (RVC) standard from MPEG (ISO / IEC SC29WG11) defines a library of coding tools to specify existing or new compressed video formats and decoders. The coding tool library has been written in a dataflow/actor-oriented language named CAL. Each coding tool (actor) can be represented with an extended finite state machine and the data communication between the tools are described as dataflow graphs. This paper proposes an approach to model the CAL actor network with Parameterized Synchronous Data Flow and to derive a quasi-static multiprocessor execution schedule for the system. In addition to proposing a scheduling approach for RVC, an extension to the well-known permutation flow shop scheduling problem that enables rapid run-time scheduling of RVC tasks, is introduced.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), Machine Vision Group, Univ of Oulu, CRPP, Abo Akad Univ, Abo Akademi University, Dept Phys

Contributors: Boutellier, J., Lucarz, C., Lafond, S., Gomez, V. M., Mattavelli, M.

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ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Digital signal processors, Modeling, Parallel processing, Scheduling

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Source: Scopus

Source ID: 79954614566

Research output: Contribution to journal › Article › Scientific › peer-review

### **Forward simulation and inverse dipole localization with the lowest order Raviart - Thomas elements for electroencephalography**

Electroencephalography is a non-invasive imaging modality in which a primary current density generated by the neural activity in the brain is to be reconstructed based on external electric potential measurements. This paper focuses on the finite element method (FEM) from both forward and inverse aspects. The goal is to establish a clear correspondence between the lowest order Raviart-Thomas basis functions and dipole sources as well as to show that the adopted FEM approach is computationally effective. Each basis function is associated with a dipole moment and a location. Four candidate locations are tested. Numerical experiments cover two different spherical multilayer head models, four mesh resolutions and two different forward simulation approaches, one based on FEM and another based on the boundary element method (BEM) with standard dipoles as sources. The forward simulation accuracy is examined through column- and matrix-wise relative errors as well as through performance in inverse dipole localization. A closed-form approximation of dipole potential was used as the reference forward simulation. The present approach is compared to the BEM and indirectly also to the recent FEM-based subtraction approach regarding both accuracy, computation time and accessibility of implementation.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Mathematical modelling with wide societal impact (MathImpact), Aalto University, Dipartimento di Matematica, Università di Genova, University of Warwick, University of Helsinki, CNR-SPIN

Contributors: Pursiainen, S., Sorrentino, A., Campi, C., Piana, M.

Publication date: Apr 2011

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ISSN (Print): 0266-5611

Ratings:

Scopus rating (2011): CiteScore 3.4 SJR 1.208 SNIP 1.598

Original language: English

ASJC Scopus subject areas: Theoretical Computer Science, Signal Processing, Mathematical Physics, Computer Science Applications, Applied Mathematics

DOIs:

10.1088/0266-5611/27/4/045003

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Source: Scopus

Source ID: 79953662770

Research output: Contribution to journal › Article › Scientific › peer-review

### Exploiting statically schedulable regions in dataflow programs

Dataflow descriptions have been used in a wide range of Digital Signal Processing (DSP) applications, such as multi-media processing, and wireless communications. Among various forms of dataflow modeling, Synchronous Dataflow (SDF) is geared towards static scheduling of computational modules, which improves system performance and predictability. However, many DSP applications do not fully conform to the restrictions of SDF modeling. More general dataflow models, such as CAL (Eker and Janneck 2003), have been developed to describe dynamically-structured DSP applications. Such generalized models can express dynamically changing functionality, but lose the powerful static scheduling capabilities provided by SDF. This paper focuses on the detection of SDF-like regions in dynamic dataflow descriptions-in particular, in the generalized specification framework of CAL. This is an important step for applying static scheduling techniques within a dynamic dataflow framework. Our techniques combine the advantages of different dataflow languages and tools, including CAL (Eker and Janneck 2003), DIF (Hsu et al. 2005) and CAL2C (Roquier et al. 2008). In addition to detecting SDF-like regions, we apply existing SDF scheduling techniques to exploit the static properties of these regions within enclosing dynamic dataflow models. Furthermore, we propose an optimized approach for mapping SDF-like regions onto parallel processing platforms such as multi-core processors.

### General information

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Xilinx Research Labs, UBL, Department of Electrical and Computer Engineering

Contributors: Gu, R., Janneck, J. W., Raulet, M., Bhattacharyya, S. S.

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ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Cal, Dataflow, DIF, Multicore processors, Quasi-static scheduling

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Source ID: 79954601701

Research output: Contribution to journal › Article › Scientific › peer-review

### **Dimensionality reduction for data visualization**

Dimensionality reduction is one of the basic operations in the toolbox of data analysts and designers of machine learning and pattern recognition systems. Given a large set of measured variables but few observations, an obvious idea is to reduce the degrees of freedom in the measurements by representing them with a smaller set of more condensed variables. Another reason for reducing the dimensionality is to reduce computational load in further processing. A third reason is visualization.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Research Community on Data-to-Decision (D2D), Aalto University

Contributors: Kaski, S., Peltonen, J.

Number of pages: 5

Pages: 100-104

Publication date: Mar 2011

Peer-reviewed: Yes

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Original language: English

ASJC Scopus subject areas: Signal Processing, Music, Applied Mathematics, Electrical and Electronic Engineering

Keywords: Data models, Data visualization, Information retrieval, Machine learning, Manifolds, Probabilistic logic, Visualization

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Research output: Contribution to journal > Article > Scientific > peer-review

### **Topological patterns for scalable representation and analysis of dataflow graphs**

Tools for designing signal processing systems with their semantic foundation in dataflow modeling often use high-level graphical user interfaces (GUIs) or text based languages that allow specifying applications as directed graphs. Such graphical representations serve as an initial reference point for further analysis and optimizations that lead to platform-specific implementations. For large-scale applications, the underlying graphs often consist of smaller substructures that repeat multiple times. To enable more concise representation and direct analysis of such substructures in the context of high level DSP specification languages and design tools, we develop the modeling concept of topological patterns, and propose ways for supporting this concept in a high-level language. We augment the dataflow interchange format (DIF) language-a language for specifying DSP-oriented dataflow graphs-with constructs for supporting topological patterns, and we show how topological patterns can be effective in various aspects of embedded signal processing design flows using specific application examples.

#### **General information**

Publication status: Published

MoE publication type: A1 Journal article-refereed

Organisations: Signal Processing Research Community (SPRC), University of Maryland, National Instruments, Air Force Research Laboratory Information Directorate, Department of Electrical and Computer Engineering

Contributors: Sane, N., Kee, H., Seetharaman, G., Bhattacharyya, S. S.

Number of pages: 16

Pages: 229-244

Publication date: 2011

Peer-reviewed: Yes

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ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Keywords: Dataflow graphs, High-level languages, Model-based design, Signal processing systems, Topological patterns  
DOIs:

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Research output: Contribution to journal › Article › Scientific › peer-review

### **Modeling and estimation of signal-dependent and correlated noise**

The additive white Gaussian noise (AWGN) model is ubiquitous in signal processing. This model is often justified by central-limit theorem (CLT) arguments. However, whereas the CLT may support a Gaussian distribution for the random errors, it does not provide any justification for the assumed additivity and whiteness. As a matter of fact, data acquired in real applications can seldom be described with good approximation by the AWGN model, especially because errors are typically correlated and not additive. Failure to model accurately the noise leads to inaccurate analysis, ineffective filtering, and distortion or even failure in the estimation. This chapter provides an introduction to both signal-dependent and correlated noise and to the relevant models and basic methods for the analysis and estimation of these types of noise. Generic one-parameter families of distributions are used as the essential mathematical setting for the observed signals. The distribution families covered as leading examples include Poisson, mixed Poisson–Gaussian, various forms of signal-dependent Gaussian noise (including multiplicative families and approximations of the Poisson family), as well as doubly censored heteroskedastic Gaussian distributions. We also consider various forms of noise correlation, encompassing pixel and readout cross-talk, fixed-pattern noise, column/row noise, etc., as well as related issues like photo-response and gain nonuniformity. The introduced models and methods are applicable to several important imaging scenarios and technologies, such as raw data from digital camera sensors, various types of radiation imaging relevant to security and to biomedical imaging.

### **General information**

Publication status: Published

MoE publication type: A3 Part of a book or another research book

Organisations: Signal Processing, Research group: Signal and Image Restoration-RST, University of São Paulo

Contributors: Azzari, L., Borges, L. R., Foi, A.

Number of pages: 36

Pages: 1-36

Publication date: 2018

### **Host publication information**

Title of host publication: Denoising of Photographic Images and Video : Fundamentals, Open Challenges and New Trends

Publisher: SPRINGER-VERLAG LONDON LTD

ISBN (Print): 978-3-319-96028-9

### **Publication series**

Name: Advances in Computer Vision and Pattern Recognition

ISSN (Print): 2191-6586

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ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition, Artificial Intelligence

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Azzari2018-Modeling\_and\_estimation\_of\_signal\_dependent\_and\_correlated\_noise. Embargo ended: 11/09/19

DOIs:

10.1007/978-3-319-96029-6\_1

URLs:

<http://urn.fi/URN:NBN:fi:tty-201907151959>. Embargo ended: 11/09/19

Source: Scopus

Source ID: 85053409603

Research output: Chapter in Book/Report/Conference proceeding › Chapter › Scientific › peer-review

### **Data-driven stream mining systems for computer vision**

In this chapter, we discuss the state of the art and future challenges in adaptive stream mining systems for computer vision. Adaptive stream mining in this context involves the extraction of knowledge from image and video streams in real-time, and from sources that are possibly distributed and heterogeneous. With advances in sensor and digital processing

technologies, we are able to deploy networks involving large numbers of cameras that acquire increasing volumes of image data for diverse applications in monitoring and surveillance. However, to exploit the potential of such extensive networks for image acquisition, important challenges must be addressed in efficient communication and analysis of such data under constraints on power consumption, communication bandwidth, and end-to-end latency. We discuss these challenges in this chapter, and we also discuss important directions for research in addressing such challenges using dynamic, data-driven methodologies.

#### General information

Publication status: Published

MoE publication type: A3 Part of a book or another research book

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Electrical Engineering Department, University of California, Los Angeles (UCLA)

Contributors: Bhattacharyya, S. S., Van Der Schaar, M., Atan, O., Tekin, C., Sudusinghe, K.

Number of pages: 16

Pages: 249-264

Publication date: 2014

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Source ID: 84984919867

Research output: Chapter in Book/Report/Conference proceeding › Chapter › Scientific › peer-review

#### Radio-based Sensing and Indoor Mapping with Millimeter-Wave 5G NR Signals

The emerging 5G New Radio (NR) networks are expected to enable huge improvements, e.g., in terms of capacity, number of connected devices, peak data rates and latency, compared to existing networks. At the same time, a new trend referred to as the RF convergence is aiming to jointly integrate communications and sensing functionalities into the same systems and hardware platforms. In this paper, we investigate the sensing prospects of 5G NR systems, with particular emphasis on the user equipment side and their potential for joint communications and environment mapping. To this end, a radio-based sensing approach utilizing the 5G NR uplink transmit signal and an efficient receiver processing and mapping scheme are proposed. An indoor scenario is then studied and evaluated through real-world RF measurements at 28 GHz mm-wave band, showing that impressive mapping performance can be achieved by the proposed system. The measurement data is available at a permanent open repository.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning, Tampere University

Contributors: Barneto, C. B., Riihonen, T., Turunen, M., Koivisto, M., Talvitie, J., Valkama, M.

Number of pages: 5

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Publisher: IEEE

Editors: Nurmi, J., Lohan, E., Torres-Sospedra, J., Kuusniemi, H., Ometov, A.

ISBN (Electronic): 9781728164557

#### Publication series

Name: 2020 International Conference on Localization and GNSS, ICL-GNSS 2020 - Proceedings

ISSN (Electronic): 2325-0771

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Aerospace Engineering, Control and Optimization



Keywords: 5G New Radio (NR), indoor mapping, joint communications and sensing, mm-waves., RF convergence  
Electronic versions:

ICL\_2020\_Radio\_Mapping\_Carlos\_et\_al

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URLs:

<http://urn.fi/URN:NBN:fi:tuni-202008266698>

Source: Scopus

Source ID: 85089434480

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Positioning Based on Noise-Limited Censored Path Loss Data**

Positioning is considered one of the most important features and enabler of various novel industry verticals in future radio systems. Since path loss or received signal strength-based measurements are widely available and accessible in the majority of wireless standards, path loss-based positioning has an important role among other positioning technologies. Conventionally path loss-based positioning has two phases; i) fitting a path loss model to training data, if such training data is available, and ii) determining link distance estimates based on the path loss model and calculating the position estimate. However, in both phases, the maximum measurable path loss is limited by measurement noise. Such immeasurable samples are called censored path loss data and such noisy data is commonly neglected in both the model fitting and in the positioning phase. In the case of censored path loss, the loss is known to be above a known threshold level and that information can be used in model fitting as well as in the positioning phase. In this paper, we examine and propose how to use censored path loss data in path loss model-based positioning and demonstrate with simulations the potential of the proposed approach for considerable improvements (over 30%) in positioning accuracy.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning

Contributors: Karttunen, A., Valkama, M., Talvitie, J.

Number of pages: 6

Publication date: Jun 2020

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Editors: Nurmi, J., Lohan, E., Torres-Sospedra, J., Kuusniemi, H., Ometov, A.

ISBN (Electronic): 9781728164557

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Name: 2020 International Conference on Localization and GNSS, ICL-GNSS 2020 - Proceedings

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Aerospace Engineering, Control and Optimization

Keywords: censored data, localization, maximum-likelihood estimation, path loss, path loss model, positioning, probabilistic modeling., shadow fading, wireless networks

DOIs:

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Source: Scopus

Source ID: 85089428732

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Modeling and Mitigating 5G Wireless Downlink Interferences for Low-altitude Aerial vehicles**

Future 5G networks will serve both terrestrial and aerial users, thanks to their network slicing and flexible numerology capabilities. The probability of Line-of-Sight (LoS) propagation will be intuitively higher for aerial users than for terrestrial users and this will provide a trade-off between increased capacity and increased interference. Our paper analyzes theoretically this trade-off and proposes solutions based on downlink multiantenna beamforming and joint optimization of the signal-to-interference ratio of multiple aerial users. It is shown that Multiple-Input-Single-Output solutions offer the most convenient tradeoff between complexity and capacity/interference performance. Simulation results are provided for mm Wave bands and low-altitude aerial vehicles.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning, Airbus Germany

Contributors: Wang, W., Fath, T., Valkama, M., Lohan, E. S.

Number of pages: 6  
Publication date: Jun 2020

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Editors: Nurmi, J., Lohan, E., Torres-Sospedra, J., Kuusniemi, H., Ometov, A.  
ISBN (Electronic): 9781728164557

#### Publication series

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ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Aerospace Engineering, Control and Optimization  
Keywords: autonomous aerial vehicles, communication links, drones, interference, Multiple-Input-Single-Output (MISO), Signal-to-Interference Ratio (SIR)  
DOIs:  
10.1109/ICL-GNSS49876.2020.9115534  
Source: Scopus  
Source ID: 85089441034  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Analog Mitigation of Frequency-Modulated Interference for Improved GNSS Reception

Powerful in-band interference can saturate a receiver's front-end and limit the usefulness of digital interference suppression methods that are bounded by the receiver's limited dynamic range. This is especially true for the self-interference (SI) encountered in full-duplex (FD) radios, but also in the case of strong interference between co-located radios. However, unlike in FD radios, receivers co-located with interference sources do not typically have direct access to the transmitted interference. This work analyzes the performance of a digitally-assisted analog interference mitigation method and its implementation for the suppression of frequency-modulated (FM) interference before quantization in global navigation satellite system (GNSS) receivers that are co-located with interference sources. Over-the-air measurement results are presented that illustrate the effects of interference mitigation on GPS L1 and Galileo E1 reception in a commercial off-the-shelf GNSS receiver and a software-defined GNSS receiver. The analysis covers the effects of the interference mitigation on the radio frequency (RF) front-end, acquisition, tracking, and positioning stages.

#### General information

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning, Rantelon  
Contributors: Parlin, K., Riihonen, T.  
Number of pages: 6  
Publication date: Jun 2020

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Title of host publication: 2020 International Conference on Localization and GNSS, ICL-GNSS 2020 - Proceedings  
Publisher: IEEE  
Editors: Nurmi, J., Lohan, E., Torres-Sospedra, J., Kuusniemi, H., Ometov, A.  
ISBN (Electronic): 9781728164557

#### Publication series

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ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Aerospace Engineering, Control and Optimization  
DOIs:  
10.1109/ICL-GNSS49876.2020.9115518  
Source: Scopus  
Source ID: 85089433388  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Adaptive Normalization for Forecasting Limit Order Book Data Using Convolutional Neural Networks

Deep learning models are capable of achieving state-of-the-art performance on a wide range of time series analysis tasks. However, their performance crucially depends on the employed normalization scheme, while they are usually unable to efficiently handle non-stationary features without first appropriately pre-processing them. These limitations impact the performance of deep learning models, especially when used for forecasting financial time series, due to their non-stationary and multimodal nature. In this paper we propose a data-driven adaptive normalization layer which is capable of learning the most appropriate normalization scheme that should be applied on the data. To this end, the proposed method first identifies the distribution from which the data were generated and then it dynamically shifts and scales them in order to facilitate the task at hand. The proposed normalization scheme is fully differentiable and it is trained in an end-to-end

fashion along with the rest of the parameters of the model. The proposed method leads to significant performance improvements over several competitive normalization approaches, as demonstrated using a large-scale limit order book dataset.

#### General information

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MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Research group: Multimedia Research Group - MRG, Aristotle University of Thessaloniki, Aarhus Universitet

Contributors: Passalis, N., Tefas, A., Kannianen, J., Gabbouj, M., Iosifidis, A.

Number of pages: 5

Pages: 1713-1717

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Publisher: IEEE

ISBN (Electronic): 9781509066315

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ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

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#### Bibliographical note

EXT="Tefas, Anastasios"

EXT="Iosifidis, Alexandros"

Source: Scopus

Source ID: 85089240342

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Peer to Peer Offloading with Delayed Feedback: An Adversary Bandit Approach

Fog computing brings computation and services to the edge of networks enabling real time applications. In order to provide satisfactory quality of experience, the latency of fog networks needs to be minimized. In this paper, we consider a peer computation offloading problem for a fog network with unknown dynamics. Peer competition occurs when different fog nodes offload tasks to the same peer FN. In this paper, the computation offloading problem is modeled as a sequential FN selection problem with delayed feedback. We construct an online learning policy based on the adversary multi-arm bandit framework to deal with peer competition and delayed feedback. Simulation results validate the effectiveness of the proposed policy.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning, Shanghai Advanced Research Institute, Chinese Academy of Sciences, ShanghaiTech University, Shanghai Institute of Microsystem and Information Technology Chinese Academy of Sciences, Peoples' Friendship University of Russia

Contributors: Yang, M., Zhu, H., Wang, H., Koucheryavy, Y., Samouylov, K., Qian, H.

Number of pages: 5

Pages: 5035-5039

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ISSN (Print): 1520-6149

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: adversary multi-arm bandit, delayed feed-back, Fog computing, reinforcement learning, task offloading  
DOIs:

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Source: Scopus

Source ID: 85089215773

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **5G new radio evolution towards sub-THz communications**

In this paper, the potential of extending 5G New Radio physical layer solutions to support communications in sub-THz frequencies is studied. More specifically, we introduce the status of third generation partnership project studies related to operation on frequencies beyond 52.6 GHz and note also the recent proposal on spectrum horizons provided by federal communications commission (FCC) related to experimental licenses on 95 GHz-3 THz frequency band. Then, we review the power amplifier (PA) efficiency and output power challenge together with the increased phase noise (PN) distortion effect in terms of the supported waveforms. As a practical example on the waveform and numerology design from the perspective of the PN robustness, link performance results using 90 GHz carrier frequency are provided. The numerical results demonstrate that new, higher subcarrier spacings are required to support high throughput, which requires larger changes in the physical layer design. It is also observed that new phase-tracking reference signal designs are required to make the system robust against PN. The results illustrate that single-carrier frequency division multiple access is significantly more robust against PN and can provide clearly larger PA output power than cyclic-prefix orthogonal frequency division multiplexing, and is therefore a highly potential waveform for sub-THz communications.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning, Bell Labs

Contributors: Tervo, O., Levanen, T., Pajukoski, K., Hulkkonen, J., Wainio, P., Valkama, M.

Number of pages: 6

Publication date: 1 Mar 2020

#### **Host publication information**

Title of host publication: 2nd 6G Wireless Summit 2020 : Gain Edge for the 6G Era, 6G SUMMIT 2020

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ISBN (Electronic): 9781728160474

ASJC Scopus subject areas: Artificial Intelligence, Hardware and Architecture, Signal Processing, Safety, Risk, Reliability and Quality, Computer Networks and Communications, Instrumentation

Keywords: 5G New Radio, 5G NR, Beyond 5G, DFT-s-OFDM, numerology, OFDM, Phase noise, PHY, physical layer, PN, PTRS, SC-FDMA, Spectrum availability, Sub-THz

DOIs:

10.1109/6GSUMMIT49458.2020.9083807

Source: Scopus

Source ID: 85086306147

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Protective Coating Methods for Glove-Integrated RFID Tags - A Preliminary Study**

In this study, machine washing durability of working glove-integrated passive RFID tags is evaluated. These glove-tags are embedded inside 3D-printed thermoplastic polyurethane platforms. The results are compared to platforms embedded inside brush-painted encapsulant platforms. For a preliminary washing reliability evaluation, both types of glove-integrated platforms are washed in a washing machine for 5 times. Although both platforms can protect glove-tags from the effects of water, the main reliability challenge is found to be the fragile antenna-IC attachments. This paper introduces the two platform materials and the achieved washing test results. These preliminary results determine the future direction of this research: The next step is to study suitable methods to strengthen the interconnections, so that these glove-tags can survive the harsh environment inside a washing machine.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: BioMediTech, Research group: Wireless Identification and Sensing Systems Research Group

Contributors: Khan, Z., He, H., Chen, X., Ukkonen, L., Virkki, J.

Publication date: 1 Mar 2020

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#### Publication series

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ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Instrumentation, Radiation

Keywords: Gloves, passive UHF RFID, protective coatings, reliability evaluation, washing

DOIs:

10.23919/EuCAP48036.2020.9135632

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Source ID: 85088649095

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Headband Antenna for Wireless Power Transfer to Millimeter-Sized Neural Implants with Minimal Misalignment Effects

We present a headband loop antenna for wireless power transfer to multiple IMDs located in the cranial cavity at the depth of 10 mm from the skin. We characterize the wireless power transfer link in terms of the power gain and the power delivered to the IMD, when maximum SAR compliant transmission power is fed to the headband antenna at frequency of 5 MHz. We also consider two types of the misalignments i.e. lateral and angular, between the IMD antenna and the headband antenna and discuss their impact on the transducer gain, impedance matching and on the power delivered to the IMD.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: BioMediTech, Research group: Wireless Identification and Sensing Systems Research Group

Contributors: Ahmed, S., Sydänheimo, L., Ukkonen, L., Björninen, T.

Number of pages: 4

Publication date: 1 Mar 2020

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ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Instrumentation, Radiation

Keywords: energy harvesting, implantable antenna, intracranial implants, power transfer efficiency., wireless inductive powering

DOIs:

10.23919/EuCAP48036.2020.9135977

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Source ID: 85088647197

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Circularly Polarized Corner-Truncated and Slotted Microstrip Patch Antenna on Textile Substrate for Wearable Passive UHF RFID Tags

We present a compact circularly polarized (CP) antenna for wearable passive UHF RFID tags. The antenna is a square-shaped microstrip patch antenna where we have applied corner truncation and slotting techniques in the top layer conductor for achieving the CP property and a shorting pin and loop structure for impedance matching. Despite using a lowpermittivity textile as antenna substrate, the antenna's footprint size is only 5-by-5 cm, which is approximately 15% of the operating wavelength. At the same time, the on-body measurements, the antenna's axial ratio is 0.9 dB and the measured attainable read range (reader's EIRP = 3.28W) of the tag reaches 4.2 meters with a CP reader antenna and ranges from 2.9 meters to 3.4 meters for a linear reader antenna, depending on the rotation angle between the antennas.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: BioMediTech, Research group: Wireless Identification and Sensing Systems Research Group

Contributors: Le, D., Ukkonen, L., Björninen, T.

Number of pages: 5

Publication date: 1 Mar 2020

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#### Publication series

Name: 14th European Conference on Antennas and Propagation, EuCAP 2020

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Instrumentation, Radiation

Keywords: circular polarization, RFID tag, UHF, wearable antenna

DOIs:

10.23919/EuCAP48036.2020.9135984

Source: Scopus

Source ID: 85088645766

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Measurements of Reflection and Penetration Losses in Low Terahertz Band Vehicular Communications

The beyond-5G vehicular communications are expected not only to utilize the already explored millimeter-wave band but also to start harnessing the higher frequencies above 100 GHz ultimately targeting the so-called low terahertz band, 300 GHz-1 THz. In this paper, we perform a set of propagation measurements at 300 GHz band in representative vehicular environments. Particularly, we report on the reflection losses from the front, rear, and side of a regular vehicle. In addition, the penetration losses when propagating through, over, and under the vehicle are presented. Our study reveals that the vehicle body is extremely heterogeneous in terms of the propagation losses: the attenuation heavily depends on the trajectory of the 300 GHz signal through the vehicle. The reported measurement data may be used as a reference when developing the vehiclespecific channel and interference models for future wireless communications in the low terahertz band.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Technische Universität Braunschweig

Contributors: Petrov, V., Eckhardt, J. M., Moltchanov, D., Koucheryavy, Y., Kurner, T.

Number of pages: 5

Publication date: 1 Mar 2020

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ISBN (Electronic): 9788831299008

#### Publication series

Name: 14th European Conference on Antennas and Propagation, EuCAP 2020

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Instrumentation, Radiation

Keywords: low terahertz, penetration losses, Propagation measurements, reflection losses, vehicular communications.

DOIs:

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Source: Scopus

Source ID: 85088642836

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Towards Asteroid Tomography: Modellings and Measurements Using an Analogue Model

The interior structures of the comets and asteroids, still poorly known, might hold a unique key to understand the early Solar System. Considering the interaction of an illuminated electromagnetic wave with this kind of targets, these 'objects' are very large compared to the applicable wavelength. Consequently, tomographic imaging of such targets, i.e., reconstructing their interior structure via multiple measurements, constitutes a challenging inverse problem. To reach this objective and to develop and test inverse algorithms, we need to investigate electromagnetic fields that have interacted with structures analogous to real asteroids and comets. In this study, we focus on the acquisition of these fields considering three methods: calculated fields obtained with (1) time and (2) frequency domain methods and (3) microwave measurements performed for an analogue model, i.e., a small-scale asteroid model.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, UMR 7249, G2Elab/Institut Néel

Contributors: Eyraud, C., Sorsa, L. I., Herique, A., Geffrin, J. M., Pursiainen, S., Kofman, W.

Number of pages: 4

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Name: 14th European Conference on Antennas and Propagation, EuCAP 2020

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Instrumentation, Radiation

Keywords: 3D inversion, Analogue model, Electromagnetic wave, Large targets, Microwave analogy, Microwave imaging

DOIs:

10.23919/EuCAP48036.2020.9136060

Source: Scopus

Source ID: 85088663343

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Passive RFID-based Textile Touchpad

This paper presents the first prototype of a passive RFID-based textile touchpad. Our unique solution takes advantage of ICs from passive UHF RFID technology. These components are combined into a textile-integrated IC array, which can be used for handwritten character recognition. As the solution is fully passive and gets all the needed energy from the RFID reader, it enables a maintenance-free and cost-effective user interface that can be integrated into clothing and into textiles around us.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: BioMediTech, Research group: Wireless Identification and Sensing Systems Research Group, Computing Sciences, Research group: Machine Learning Group MLG, Research group: Vision

Contributors: He, H., Chen, X., Raivio, L., Huttunen, H., Virkki, J.

Number of pages: 4

Publication date: 2020

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Article number: 9135201

ISBN (Print): 978-1-7281-3712-4

ISBN (Electronic): 9788831299008

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Instrumentation, Radiation

Keywords: passive UHF RFID, textile electronics, touchpad, user interface, wearable electronics

DOIs:

10.23919/EuCAP48036.2020.9135201

Source: Scopus

Source ID: 85088635326

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Constrained PSK: Energy-efficient modulation for Sub-THz systems

Deploying sub-THz frequencies for mobile communications is one timely research area, due to the availability of very wide and contiguous chunks of the radio spectrum. However, at such extremely high frequencies, there are large challenges related to, e.g., phase noise, propagation losses as well as to energy-efficiency, since generating and radiating power with reasonable efficiency is known to be far more difficult than at lower frequencies. To address the energy-efficiency and power amplifier (PA) nonlinear distortion related challenges, modulation methods and waveforms with low peak-to-average-power ratio (PAPR) are needed. To this end, a new modulation approach is formulated and proposed in this paper, referred to as constrained phase-shift keying (CPSK). The CPSK concept builds on the traditional PSK constellations, while additional constraints are applied to the time domain symbol transitions in order to control and reduce the PAPR of the resulting waveform. This new modulation is then compared with pulse-shaped  $\pi/2$ -BPSK and ordinary QPSK, in the discrete Fourier transform (DFT) spread orthogonal frequency division multiplexing (DFT-s-OFDM) context, in terms of the resulting PAPR distributions and the achievable maximum PA output power, subject to constraints in the passband waveform quality and out-of-band emissions. The obtained results show that the proposed CPSK approach allows for reducing the PAPR and thereon for achieving higher PA output powers, compared to QPSK, while still offering the same spectral efficiency. Overall, the CPSK concept offers a flexible modulation solution with controlled PAPR for the future sub-THz networks.

### General information

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MoE publication type: A4 Article in a conference publication  
Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning  
Contributors: Nasarre, I. P., Levanen, T., Valkama, M.  
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Keywords: 5G New Radio (NR) evolution, DFT-s-OFDM, Energy-efficiency, Modulation, PAPR, Power amplifiers, Sub-THz communications  
DOIs:  
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Source ID: 85090293993  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Reinforcement learning for improved UAV-based integrated access and backhaul operation

There is a strong interest in utilizing commercial cellular networks to support unmanned aerial vehicles (UAVs) to send control commands and communicate heavy traffic. Cellular networks are well suited for offering reliable and secure connections to the UAVs as well as facilitating traffic management systems to enhance safe operation. However, for the full-scale integration of UAVs that perform critical and high-risk tasks, more advanced solutions are required to improve wireless connectivity in mobile networks. In this context, integrated access and backhaul (IAB) is an attractive approach for the UAVs to enhance connectivity and traffic forwarding. In this paper, we study a novel approach to dynamic associations based on reinforcement learning at the edge of the network and compare it to alternative association algorithms. Considering the average data rate, our results indicate that the reinforcement learning methods improve the achievable data rate. The optimal parameters of the introduced algorithm are highly sensitive to the donor next generation node base (DgNB) and UAV IAB node densities, and need to be identified beforehand or estimated via a stateful search. However, its performance nearly converges to that of the ideal scheme with a full knowledge of the data rates in dense deployments of DgNBs.

#### General information

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Electrical Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Research group: Wireless Communications and Positioning, Intel Corporation  
Contributors: Tafintsev, N., Moltchanov, D., Simsek, M., Yeh, S. P., Andreev, S., Koucheryavy, Y., Valkama, M.  
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#### **Bibliographical note**

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Source ID: 85090294995

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### **Comparing capacity gains of static and UAV-based millimeter-wave relays in clustered deployments**

The prospective millimeter-wave (mmWave) networks are envisioned to heavily utilize relay nodes to improve their performance in certain scenarios. In addition to the stationary mmWave relays already considered by 3GPP as one of the main focuses, the community recently started to explore the use of unmanned aerial vehicle (UAV)-based mmWave relays. These aerial nodes provide greater flexibility in terms of the relay placement in different environments as well as the ability to optimize the deployment height thus maximizing the cell performance. At the same time, the use of UAV-based relays leads to additional deployment complexity and expenditures for the network operators. In this paper, taking into account 3GPP-standardized mmWave-specific propagation, blockage, and resource allocation we compare the capacity gains brought by the static and the UAV-based mmWave relays in different scenarios. For each of the relay types, we investigate both uniform and clustered distribution of human users. The developed mathematical framework and a numerical study reveal that the highest capacity gains when utilizing the UAV-based relays instead of the static ones are observed in clustered deployments (up to 31%), while the performance difference between the UAV-based and the static mmWave relays under a uniform distribution of users is just 3%.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Research group: Wireless Communications and Positioning, Intel Corporation

Contributors: Gapeyenko, M., Petrov, V., Moltchanov, D., Yeh, S. P., Himayat, N., Andreev, S.

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Keywords: 5G, MmWave, New Radio, Relay, UAV

DOIs:

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#### **Bibliographical note**

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Source ID: 85090293224

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### **Parametric exploration of cellular swelling in a computational model of cortical spreading depression**

Cortical spreading depression (CSD) is a slowly propagating wave of depolarization of brain cells, followed by temporary silenced electrical brain activity. Major structural changes during CSD are linked to neuronal and possibly glial swelling. However, basic questions still remain unanswered. In particular, there are open questions regarding whether neurons or glial cells swell more, and how the cellular swelling affects the CSD wave propagation. In this study, we computationally explore how different parameters affect the swelling of neurons and astrocytes (starshaped glial cells) during CSD and

how the cell swelling alters the CSD wave spatial distribution. We apply a homogenized mathematical model that describes electrodiffusion in the intraand extracellular space, and discretize the equations using a finite element method. The simulations are run with a twocompartment (extracellular space and neurons) and a threecompartment version of the model with astrocytes added. We consider cell swelling during CSD in four scenarios: (A) incorporating aquaporin-4 channels in the astrocytic membrane, (B) increasing the neuron/astrocyte ratio to 2:1, (C) blocking and increasing the  $\text{Na}^+/\text{K}^+$ -ATPase rate in the astrocytic compartment, and (D) blocking the  $\text{Cl}^-$  channels in astrocytes. Our results show that increasing the water permeability in the astrocytes results in a higher astrocytic swelling and a lower neuronal swelling than in the default case. Further, elevated neuronal density increases the swelling in both neurons and astrocytes. Blocking the  $\text{Na}^+/\text{K}^+$ -ATPase in the astrocytes leads to an increased wave width and swelling in both compartments, which instead decreases when the pump rate is raised. Blocking the  $\text{Cl}^-$  channels in the astrocytes results in neuronal swelling, and a shrinkage in the astrocytes. Our results suggest a supporting role of astrocytes in preventing cellular swelling and CSD, as well as highlighting how dysfunctions in astrocytes might elicit CSD.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: BioMediTech, Research group: Computational Biophysics and Imaging Group, Centre for Molecular Medicine Norway, Nordic European Molecular Biology Laboratory Partnership, University of Oslo, University of California San Diego, Simula Research Laboratory

Contributors: Genocchi, B., Cunha, A., Jain, S., Hyttinen, J., Lenk, K., Ellingsrud, A. J.

Number of pages: 5

Pages: 2491-2495

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Publisher: IEEE

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ASJC Scopus subject areas: Signal Processing, Biomedical Engineering, Computer Vision and Pattern Recognition, Health Informatics

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Source ID: 85091006468

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Prototyping directional UAV-based wireless access and backhaul systems

Providing sufficient mobile coverage during mass public events or critical situations is a highly challenging task for the network operators. To fulfill the extreme capacity and coverage demands within a limited area, several augmenting solutions might be used. Among them, novel technologies like a fleet of compact base stations mounted on Unmanned Aerial Vehicles (UAVs) are gaining momentum because of their time- and cost- efficient deployment. Despite the fact that the concept of aerial wireless access networks has been investigated recently in many research studies, there are still numerous practical aspects that require further understanding and extensive evaluation. Taking this as a motivation, in this paper, we develop the concept of continuous wireless coverage provisioning by the means of UAVs and assess its usability in mass scenarios with thousands of users. With our system-level simulations as well as a measurement campaign, we take into account a set of important parameters including weather conditions, UAV speed, weight, power consumption, and millimeter- wave (mmWave) antenna configuration. As a result, we provide more realistic data about the performance of the access and backhaul links together with the practical lessons learned about the design and real-world applicability of the UAV-enabled wireless access networks.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Department of Telecommunications, Brno University of Technology

Contributors: Gerasimenko, M., Pokorny, J., Schneider, T., Sirjov, J., Andreev, S., Hosek, J.

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ASJC Scopus subject areas: Computer Networks and Communications, Hardware and Architecture, Information Systems, Signal Processing, Information Systems and Management, Safety, Risk, Reliability and Quality, Media Technology, Health Informatics

DOIs:

10.1109/GLOBECOM38437.2019.9014228

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Optimized wake-up scheme with bounded delay for energy-efficient MTC**

The limitations of state-of-the-art cellular modems prevent achieving low-power and low-latency Machine Type Communications (MTC) based on current power saving mechanisms alone. Recently, the concept of wake-up scheme has been proposed to enhance battery lifetime of 5G devices, while reducing the buffering delay. The existing wake-up algorithms use static operational parameters that are determined by the radio access network at the start of the user's session. In this paper, the average power consumption of the wake-up enabled MTC UE is modeled by using a semi-Markov process and then optimized through a delay-constrained optimization problem, by which the optimal wake-up cycle is obtained in closed form. Numerical results show that the proposed solution reduces the power consumption of an optimized Discontinuous Reception (DRX) scheme by up to 40% for a given delay requirement.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Helsinki RanD Center, Huawei Technologies Oy (Finland). Co. Ltd., Centre Tecnologic de Telecomunicacions de Catalunya

Contributors: Rostami, S., Lagen, S., Costa, M., Dini, P., Valkama, M.

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ASJC Scopus subject areas: Computer Networks and Communications, Hardware and Architecture, Information Systems, Signal Processing, Information Systems and Management, Safety, Risk, Reliability and Quality, Media Technology, Health Informatics

Keywords: 5G, DRX, Energy efficiency, MTC, Wake-up schemes

DOIs:

10.1109/GLOBECOM38437.2019.9013534

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Gamified coding: Toy robots and playful learning in early education**

This paper explores the activity of coding with smart toy robots Dash and Botley as a part of playful learning in the Finnish early education context. The findings of our study demonstrate how coding with the two toy robots was approached, conducted and played by Finnish preschoolers aged 5-6 years. The main conclusion of the study is that preschoolers used the toy robots with affordances related to coding mainly in developing gamified play around them by designing tracks for the toys, programming the toys to solve obstacle paths, and competing in player-generated contests of dexterity, speed and physically mobile play.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Research group: TUT Game Lab, University of Turku School of Cultural Production and Landscape Studies, Prizztech Ltd.

Contributors: Heljakka, K., Ihamaki, P., Tuomi, P., Saarikoski, P.

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Keywords: Coding, Gamification, Physical play, Programming, Toy robots

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Source: Scopus

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Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **V2X Connectivity: From LTE to Joint Millimeter Wave Vehicular Communications and Radar Sensing**

To meet the prospective demands of intelligent transportation systems (ITS), the Release 14 (Rel-14) and Rel-15 of the Long Term Evolution (LTE) specifications include solutions for enhanced vehicle-to-everything (V2X) communications. While the technical enablers of Rel-14 are suitable for delivering basic safety messages, Rel-15 supports more demanding ITS services with stringent latency and reliability. Starting in Rel-15 and continuing in Rel-16, the 3GPP was developing a novel radio interface for 5G systems, termed the New Radio (NR), which will enable ultra reliable and low latency communications suitable even for the most demanding ITS applications. In this paper, we overview the new V2X-specific features in Rel-15 and Rel-16. Further, we argue that future V2X and automotive radar systems may reuse common equipment, such as millimeter-wave antenna arrays. We finally discuss the vision of joint vehicular communications and radar sensing as well as characterize unified channel access for millimeter-wave vehicular communications and radar sensing.

#### **General information**

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Organisations: Electrical Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Ericsson Research, Ericsson Research, Kungliga Tekniska Högskolan KTH

Contributors: Petrov, V., Fodor, G., Andreev, S., Do, H., Sahlin, H.

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Editor: Matthews, M. B.

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ASJC Scopus subject areas: Signal Processing, Computer Networks and Communications

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Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Closed-Loop DPD for Digital MIMO Transmitters under Antenna Crosstalk**

Due to the closely-spaced antenna elements in large array or massive MIMO transmitters, antenna crosstalk is inevitable. This imposes additional challenges when seeking to linearize the power amplifiers at the transmitter through digital predistortion (DPD). In the commonly applied indirect learning architecture (ILA), the antenna crosstalk is known to result in a large amount of additional basis functions (BFs) in order to account for all the coupling signal terms and achieve good linearization. In this article, we propose a novel closed-loop DPD architecture and associated parameter learning algorithms that can provide efficient linearization of digital MIMO transmitters under antenna crosstalk. The proposed solution does not need extra basis functions, and is thus shown to provide large benefits in terms of computational complexity compared to existing state-of-the-art. Comprehensive numerical results are also provided, showing excellent linearization performance outperforming the existing reference methods.

#### **General information**

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Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning  
Contributors: Brihuega, A., Abdelaziz, M., Anttila, L., Barneto, C. B., Valkama, M.  
Number of pages: 8  
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Source: Scopus  
Source ID: 85083287470  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Fast fourier color constancy and grayness index for ISPA illumination estimation challenge

We briefly introduce two submissions to the Illumination Estimation Challenge, in the Int'l Workshop on Color Vision, affiliated to the 11th Int'l Symposium on Image and Signal Processing and Analysis. The fourier-transform-based submission is ranked 3rd, and the statistical Gray-pixel-based one ranked 6th.

#### General information

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Computing Sciences, South China University of Technology  
Contributors: Qian, Y., Chen, K., Yu, H.  
Number of pages: 3  
Pages: 352-354  
Publication date: 17 Oct 2019

#### Host publication information

Title of host publication: ISPA 2019 - 11th International Symposium on Image and Signal Processing and Analysis  
Publisher: IEEE  
Editors: Loncaric, S., Bregovic, R., Carli, M., Subasic, M.  
ISBN (Electronic): 9781728131405

#### Publication series

Name: International Symposium on Image and Signal Processing and Analysis, ISPA  
Volume: 2019-September  
ISSN (Print): 1845-5921  
ISSN (Electronic): 1849-2266  
ASJC Scopus subject areas: Computational Theory and Mathematics, Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Signal Processing  
Keywords: Color constancy, FFCC, Gray pixel, Illumination  
DOIs:  
10.1109/ISPA.2019.8868451

#### Bibliographical note

EXT="Chen, Ke"  
Source: Scopus  
Source ID: 85074428933  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Towards Algebraic Modeling of GPU Memory Access for Bank Conflict Mitigation**

Graphics Processing Units (GPU) have been widely used in various fields of scientific computing, such as in signal processing. GPUs have a hierarchical memory structure with memory layers that are shared between GPU processing elements. Partly due to the complex memory hierarchy, GPU programming is non-Trivial, and several aspects must be taken into account, one being memory access patterns. One of the fastest GPU memory layers, shared memory, is grouped into banks to enable fast, parallel access for processing elements. Unfortunately, it may happen that multiple threads of a GPU program may access the same shared memory bank simultaneously causing a bank conflict. If this happens, program execution slows down as memory accesses have to be rescheduled to determine which instruction to execute first. Bank conflicts are not taken into account automatically by the compiler, and hence the programmer must detect and deal with them prior to program execution. In this paper, we present an algebraic approach to detect bank conflicts and prove some theoretical results that can be used to predict when bank conflicts happen and how to avoid them. Also, our experimental results illustrate the savings in computation time.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Research area: Computer engineering, Tampere University

Contributors: Ferranti, L., Boutellier, J.

Number of pages: 6

Pages: 103-108

Publication date: 1 Oct 2019

#### **Host publication information**

Title of host publication: 2019 IEEE International Workshop on Signal Processing Systems, SiPS 2019

Publisher: IEEE

ISBN (Electronic): 9781728119274

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics, Hardware and Architecture

Keywords: block matching, Graphics processing units, memory hierarchy, OpenCL

DOIs:

10.1109/SiPS47522.2019.9020385

#### **Bibliographical note**

INT=comp,"Ferranti, Luca"

Source: Scopus

Source ID: 85082393531

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **A perspective on wireless M-bus for smart electricity grids**

The Internet of Things (IoT) enables long-range outdoor networks, such as smart grid and municipal lighting, as well as short-range indoor systems for smart homes, residential security, and energy management. Wireless connectivity and standardized communication protocols become an essential technology baseline for these diverse IoT applications. The focus of this work is wireless connectivity for smart metering systems. One of the recent protocols in this field is Wireless M-BUS, which is being widely utilized for remote metering applications across Europe. Therefore, in this paper, we detail a novel multi-platform framework designed to serve as a data generator for the protocol in question. The developed software allows to construct Wireless M-Bus telegrams with a high level of detail according to the EN 13757-4 specification and then schedule them for periodic transmission. The evaluation of the data generator is done in real scenario by using previously developed prototype equipped with IQRF TR72DA communication module acting as a smart meter with implemented software framework. As a result, the evaluation of communication distance between the developed Wireless MBus prototype and commercial gateway was tested in case of indoor scenario at Brno University of Technology, Faculty of Electrical Engineering and Communication.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Brno University of Technology, Department of Telecommunication

Contributors: Masek, P., Stusek, M., Zeman, K., Mozny, R., Ometov, A., Hosek, J.

Number of pages: 6

Pages: 730-735

Publication date: 1 Jul 2019

#### **Host publication information**

Title of host publication: 2019 42nd International Conference on Telecommunications and Signal Processing, TSP 2019

Publisher: IEEE

Editor: Herencsar, N.

ISBN (Electronic): 9781728118642

ASJC Scopus subject areas: Signal Processing, Computer Networks and Communications, Information Systems and Management

Keywords: Data generator, Energy efficient wireless communication, Low power communication, Machine-to-Machine, Smart Grid, Wireless M-BUS

Electronic versions:

A Perspective on Wireless M-Bus for Smart Electricity Grids

DOIs:

10.1109/TSP.2019.8768840

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202001151288>

#### **Bibliographical note**

EXT="Stusek, Martin"

Source: Scopus

Source ID: 85071067560

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### **On the performance of narrow-band internet of things (NB-IoT) for delay-tolerant services**

Narrowband IoT (NB-IoT) stands for a radio access technology standardized by the 3GPP organization in Release 13 to enable a large set of use-cases for massive Machine-type Communications (mMTCs). Compared to legacy human-oriented 4G (LTE) communication systems, NB-IoT has game-changing features in terms of extended coverage, enhanced power saving modes, and a reduced set of available functionality. At the end of the day, these features allow for connectivity of devices in challenging positions, enabling long battery life and reducing device complexity. This article addresses the development of the universal testing device for delay-tolerant services allowing for in-depth verification of NB-IoT communication parameters. The presented outputs build upon our long-term cooperation with the Vodafone Czech Republic a.s. company.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Brno University of Technology, Department of Telecommunication

Contributors: Mozny, R., Masek, P., Stusek, M., Zeman, K., Ometov, A., Hosek, J.

Number of pages: 6

Pages: 637-642

Publication date: 1 Jul 2019

#### **Host publication information**

Title of host publication: 2019 42nd International Conference on Telecommunications and Signal Processing, TSP 2019

Publisher: IEEE

Editor: Herencsar, N.

ISBN (Electronic): 9781728118642

#### **Publication series**

Name: 2019 42nd International Conference on Telecommunications and Signal Processing, TSP 2019

ASJC Scopus subject areas: Signal Processing, Computer Networks and Communications, Information Systems and Management

Keywords: IoT, mMTC, LPWAN, NB-IoT, Network services

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On the Performance of Narrow-band Internet of Things (NB-IoT) for Delay-tolerant Services

DOIs:

10.1109/TSP.2019.8768871

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202001151292>

#### **Bibliographical note**

EXT="Stusek, Martin"

Source: Scopus

Source ID: 85071063087

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Input magnitude data setting in error-reduction algorithm for one-dimensional discrete phase retrieval problem**

In this paper we discuss how does the input magnitude data setting influence the behavior of error-reduction algorithm in the case of the one-dimensional discrete phase retrieval problem. We present experimental results related to the convergence or stagnation of the algorithm. We also discuss the issue of the zeros distribution of the solution, when the solution of the problem exists.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, FETTI, Technical University of Cluj-NapocaUniversitatea Tehnica din Cluj-Napoca

Contributors: Rusu, C., Astola, J.

Publication date: 1 Jul 2019

#### **Host publication information**

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Publisher: IEEE

Article number: 8801743

ISBN (Electronic): 9781728138961

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

DOIs:

10.1109/ISSCS.2019.8801743

#### **Bibliographical note**

EXT="Rusu, Corneliu"

Source: Scopus

Source ID: 85071848180

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **User Experience Study of 360° Music Videos on Computer Monitor and Virtual Reality Goggles**

360° videos are increasingly used for media and entertainment, but the best practices for editing them are not yet well established. In this paper, we present a study in which we investigated the user experience of 360° music videos viewed on computer monitor and VR goggles. The research was conducted in the form of a laboratory experiment with 20 test participants. During the within-subject study, participants watched and evaluated four versions of the same 360° music video with a different cutting rate. Based on the results, an average cutting rate of 26 seconds delivered the highest-quality user experience both for computer monitor and VR goggles. The cutting rate matched with participants' mental models, and there was enough time to explore the environment without getting bored. Faster cutting rates made the users nervous, and a video consisting of a single shot was considered to be too static and boring.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Tampere University, Tampere University of Applied Sciences

Contributors: Holm, J., Väänänen, K., Remans, M. M. R.

Number of pages: 7

Pages: 81-87

Publication date: 1 Jul 2019

#### **Host publication information**

Title of host publication: Information Visualization - Biomedical Visualization and Geometric Modelling and Imaging, IV 2019

Publisher: IEEE

Editors: Banissi, E., Ursyn, A., McK. Bannatyne, M. W., Datia, N., Pires, J. M., Francese, R., Sarfraz, M., Wyeld, T. G., Bouali, F., Venturin, G., Azzag, H., Lebbah, M., Trutschl, M., Cvek, U., Muller, H., Nakayama, M., Kernbach, S., Caruccio, L., Risi, M., Erra, U., Vitiello, A., Rossano, V.

ISBN (Electronic): 9781728128382

#### **Publication series**

Name: Proceedings of the International Conference on Information Visualisation

ISSN (Print): 1093-9547

ASJC Scopus subject areas: Software, Signal Processing, Computer Vision and Pattern Recognition

Keywords: 360° video, cutting rate, hmd, music video, virtual reality, virtual reality goggles

DOIs:

10.1109/IV.2019.00023

#### **Bibliographical note**



jufoid=58079

EXT="Holm, Jukka"

INT=comp,"Remans, Mohammad Mushfiqur Rahman"

Source: Scopus

Source ID: 85072286445

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Low-latency Deep Clustering for Speech Separation

This paper proposes a low algorithmic latency adaptation of the deep clustering approach to speaker-independent speech separation. It consists of three parts: a) the usage of long-short-term-memory (LSTM) networks instead of their bidirectional variant used in the original work, b) using a short synthesis window (here 8 ms) required for low-latency operation, and, c) using a buffer in the beginning of audio mixture to estimate cluster centres corresponding to constituent speakers which are then utilized to separate speakers within the rest of the signal. The buffer duration would serve as an initialization phase after which the system is capable of operating with 8 ms algorithmic latency. We evaluate our proposed approach on two-speaker mixtures from Wall Street Journal (WSJ0) corpus. We observe that the use of LSTM yields around one dB lower SDR as compared to the baseline bidirectional LSTM in terms of source to distortion ratio (SDR). Moreover, using an 8 ms synthesis window instead of 32 ms degrades the separation performance by around 2.1 dB as compared to the baseline. Finally, we also report separation performance with different buffer durations noting that separation can be achieved even for buffer duration as low as 300 ms.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Research group: Audio research group - ARG

Contributors: Wang, S., Naithani, G., Virtanen, T.

Number of pages: 5

Pages: 76-80

Publication date: 1 May 2019

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Title of host publication: 2019 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2019 - Proceedings

Publisher: IEEE

ISBN (Electronic): 9781479981311

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Deep clustering, Low latency, Monaural speech separation

DOIs:

10.1109/ICASSP.2019.8683437

### Bibliographical note

int=comp,"Wang, Shanshan"

Source: Scopus

Source ID: 85068960960

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Time Difference of Arrival Estimation of Speech Signals Using Deep Neural Networks with Integrated Time-frequency Masking

The Time Difference of Arrival (TDoA) of a sound wavefront impinging on a microphone pair carries spatial information about the source. However, captured speech typically contains dynamic non-speech interference sources and noise. Therefore, the TDoA estimates fluctuate between speech and interference. Deep Neural Networks (DNNs) have been applied for Time-Frequency (TF) masking for Acoustic Source Localization (ASL) to filter out non-speech components from a speaker location likelihood function. However, the type of TF mask for this task is not obvious. Secondly, the DNN should estimate the TDoA values, but existing solutions estimate the TF mask instead. To overcome these issues, a direct formulation of the TF masking as a part of a DNN-based ASL structure is proposed. Furthermore, the proposed network operates in an online manner, i.e., producing estimates frame-by-frame. Combined with the use of recurrent layers it exploits the sequential progression of speaker related TDoAs. Training with different microphone spacings allows model re-use for different microphone pair geometries in inference. Real-data experiments with smartphone recordings of speech in interference demonstrate the network's generalization capability.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences

Contributors: Pertilä, P., Parviainen, M.

Number of pages: 5

Pages: 436-440  
Publication date: 1 May 2019

#### Host publication information

Title of host publication: 2019 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2019 - Proceedings

Publisher: IEEE

ISBN (Electronic): 9781479981311

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Acoustic Source Localization, Microphone Arrays, Recurrent Neural Networks, Time-Frequency Masking

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10.1109/ICASSP.2019.8682574

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002272397>

Source: Scopus

Source ID: 85068957469

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Convex Energy Optimization of Streaming Applications for MPSoCs

The energy efficiency of modern MPSoCs is enhanced by complex hardware features such as Dynamic Voltage and Frequency Scaling (DVFS) and Dynamic Power Management (DPM). This paper introduces a new method, based on convex problem solving, that determines the most energy efficient operating point in terms of frequency and number of active cores in an MPSoC. The solution can challenge the popular approaches based on never-idle (or As-Slow-As-Possible (ASAP)) and race-to-idle (or As-Fast-As-Possible (AFAP)) principles. Experimental data are reported using a Samsung Exynos 5410 MPSoC and show a reduction in energy of up to 27 % when compared to ASAP and AFAP.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Universite de Rennes

Contributors: Nogues, E., Mercat, A., Arrestier, F., Pelcat, M., Menard, D.

Number of pages: 5

Pages: 1557-1561

Publication date: 1 May 2019

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Title of host publication: 2019 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2019 - Proceedings

Publisher: IEEE

ISBN (Electronic): 9781479981311

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

DOIs:

10.1109/ICASSP.2019.8682317

Source: Scopus

Source ID: 85068997223

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Deep Reinforcement Learning for Financial Trading Using Price Trailing

Developing accurate financial analysis tools can be useful both for speculative trading, as well as for analyzing the behavior of markets and promptly responding to unstable conditions ensuring the smooth operation of the financial markets. This led to the development of various methods for analyzing and forecasting the behaviour of financial assets, ranging from traditional quantitative finance to more modern machine learning approaches. However, the volatile and unstable behavior of financial markets forbids the accurate prediction of future prices, reducing the performance of these approaches. In contrast, in this paper we propose a novel price trailing method that goes beyond traditional price forecasting by reformulating trading as a control problem, effectively overcoming the aforementioned limitations. The proposed method leads to developing robust agents that can withstand large amounts of noise, while still capturing the price trends and allowing for taking profitable decisions.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Aristotle University of Thessaloniki, School of Informatics

Contributors: Zarkias, K. S., Passalis, N., Tsantekidis, A., Tefas, A.  
Number of pages: 5  
Pages: 3067-3071  
Publication date: 1 May 2019

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Title of host publication: 2019 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2019 - Proceedings  
Publisher: IEEE  
ISBN (Electronic): 9781479981311  
ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering  
Keywords: Deep Reinforcement Learning, Financial Markets, Price Forecasting, Trading  
DOIs:  
10.1109/ICASSP.2019.8683161

#### Bibliographical note

EXT="Tefas, Anastasios"  
Source: Scopus  
Source ID: 85068989312  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### 1-D Convolutional Neural Networks for Signal Processing Applications

1D Convolutional Neural Networks (CNNs) have recently become the state-of-the-art technique for crucial signal processing applications such as patient-specific ECG classification, structural health monitoring, anomaly detection in power electronics circuitry and motor-fault detection. This is an expected outcome as there are numerous advantages of using an adaptive and compact 1D CNN instead of a conventional (2D) deep counterparts. First of all, compact 1D CNNs can be efficiently trained with a limited dataset of 1D signals while the 2D deep CNNs, besides requiring 1D to 2D data transformation, usually need datasets with massive size, e.g., in the »Big Data« scale in order to prevent the well-known »overfitting« problem. 1D CNNs can directly be applied to the raw signal (e.g., current, voltage, vibration, etc.) without requiring any pre- or post-processing such as feature extraction, selection, dimension reduction, denoising, etc. Furthermore, due to the simple and compact configuration of such adaptive 1D CNNs that perform only linear 1D convolutions (scalar multiplications and additions), a real-time and low-cost hardware implementation is feasible. This paper reviews the major signal processing applications of compact 1D CNNs with a brief theoretical background. We will present their state-of-the-art performances and conclude with focusing on some major properties. Keywords - 1-D CNNs, Biomedical Signal Processing, SHM.

#### General information

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Computing Sciences, Research group: Multimedia Research Group - MRG, Qatar University, Electrical and Electronics Engineering Department, Izmir University of Economics  
Contributors: Kiranyaz, S., Ince, T., Abdeljaber, O., Avci, O., Gabbouj, M.  
Number of pages: 5  
Pages: 8360-8364  
Publication date: 1 May 2019

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ISBN (Electronic): 9781479981311  
ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering  
DOIs:  
10.1109/ICASSP.2019.8682194

#### Bibliographical note

EXT="Kiranyaz, Serkan"  
EXT="Ince, Turker"  
Source: Scopus  
Source ID: 85068995333  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Deep Temporal Logistic Bag-of-features for Forecasting High Frequency Limit Order Book Time Series

Forecasting time series has several applications in various domains. The vast amount of data that are available nowadays provide the opportunity to use powerful deep learning approaches, but at the same time pose significant challenges of high-dimensionality, velocity and variety. In this paper, a novel logistic formulation of the well-known Bag-of-Features

model is proposed to tackle these challenges. The proposed method is combined with deep convolutional feature extractors and is capable of accurately modeling the temporal behavior of time series, forming powerful forecasting models that can be trained in an end-to-end fashion. The proposed method was extensively evaluated using a large-scale financial time series dataset, that consists of more than 4 million limit orders, outperforming other competitive methods.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, School of Informatics, Aristotle University of Thessaloniki, Aarhus Universitet

Contributors: Passalis, N., Tefas, A., Kannianen, J., Gabbouj, M., Iosifidis, A.

Number of pages: 5

Pages: 7545-7549

Publication date: 1 May 2019

#### Host publication information

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Publisher: IEEE

ISBN (Electronic): 9781479981311

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Limit Order Book, Temporal Bag-of-Features, Time series forecasting

DOIs:

10.1109/ICASSP.2019.8682297

#### Bibliographical note

EXT="Tefas, Anastasios"

EXT="Iosifidis, Alexandros"

Source: Scopus

Source ID: 85069000578

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Random Forest Oriented Fast QTBT Frame Partitioning

Block partition structure is a critical module in video coding scheme to achieve significant gap of compression performance. Under the exploration of future video coding standard by the Joint Video Exploration Team (JVET), named Versatile Video Coding (VVC), a new Quad Tree Binary Tree (QTBT) block partition structure has been introduced. In addition to the QT block partitioning defined by High Efficiency Video Coding (HEVC) standard, new horizontal and vertical BT partitions are enabled, which drastically increases the encoding time compared to HEVC. In this paper, we propose a fast QTBT partitioning scheme based on a Machine Learning approach. Complementary to techniques proposed in literature to reduce the complexity of HEVC Quad Tree (QT) partitioning, the propose solution uses Random Forest classifiers to determine for each block which partition modes between QT and BT is more likely to be selected. Using uncertainty zones of classifier decisions, the proposed complexity reduction technique is able to reduce in average by 30% the encoding time of JEM-v7.0 software in Random Access configuration with only 0.57% Bjontegaard Delta Rate (BD-BR) increase.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Universite de Rennes, MMP

Contributors: Amestoy, T., Mercat, A., Hamidouche, W., Bergeron, C., Menard, D.

Number of pages: 5

Pages: 1837-1841

Publication date: 1 May 2019

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ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Complexity Reduction, JEM, Machine Learning, QTBT, Random Forest, Video Compression, VVC

DOIs:

10.1109/ICASSP.2019.8683413

Source: Scopus

Source ID: 85068966990

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Open framework for mammography-based breast cancer risk assessment**

In recent years, several studies have established a relationship between mammographic parenchymal patterns and breast cancer risk. However, there is a lack of publicly available data and software for objective comparison and clinical validation. This paper presents an open and adaptable implementation (OpenBreast v1.0) of a fully-Automatic computerized framework for mammographic image analysis for breast cancer risk assessment. OpenBreast implements mammographic image analysis in four stages: breast segmentation, detection of region-of-interests, feature extraction and risk scoring. For each stage, we provide implementations of several state-of-The-Art methods. The pipeline is tested on a set of 305 full-field digital mammography images corresponding to 84 patients (51 cases and 49 controls) from the breast cancer digital repository (BCDR). OpenBreast achieves a competitive AUC of 0.846 in breast cancer risk assessment. In addition, used jointly with widely accepted risk factors such as patient age and breast density, mammographic image analysis using OpenBreast shows a statistically significant improvement in performance with an AUC of 0.876 ( $\text{p} < 0.001$ ). Our framework will be made publicly available and it is easy to incorporate new methods.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Research group: Vision, Universidad Industrial de Santander, Tampere University, Brigham and Women's Hospital

Contributors: Pertuz, S., Torres, G. F., Tamimi, R., Kämäräinen, J.

Publication date: 1 May 2019

#### **Host publication information**

Title of host publication: 2019 IEEE EMBS International Conference on Biomedical and Health Informatics, BHI 2019 - Proceedings

Publisher: IEEE

ISBN (Electronic): 9781728108483

ASJC Scopus subject areas: Artificial Intelligence, Signal Processing, Information Systems and Management, Biomedical Engineering, Health Informatics, Radiology Nuclear Medicine and imaging

Keywords: Breast cancer, Mammography, Parenchymal analysis, Risk assessment, Texture analysis

DOIs:

10.1109/BHI.2019.8834599

#### **Bibliographical note**

EXT="Pertuz, Said"

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Variance Preserving Initialization for Training Deep Neuromorphic Photonic Networks with Sinusoidal Activations**

Photonic neuromorphic hardware can provide significant performance benefits for Deep Learning (DL) applications by accelerating and reducing the energy requirements of DL models. However, photonic neuromorphic architectures employ different activation elements than those traditionally used in DL, slowing down the convergence of the training process for such architectures. An initialization scheme that can be used to efficiently train deep photonic networks that employ quadratic sinusoidal activation functions is proposed in this paper. The proposed initialization scheme can overcome these limitations, leading to faster and more stable training of deep photonic neural networks. The ability of the proposed method to improve the convergence of the training process is experimentally demonstrated using two different DL architectures and two datasets.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Aristotle University of Thessaloniki

Contributors: Passalis, N., Mourgias-Alexandris, G., Tsakyridis, A., Pleros, N., Tefas, A.

Number of pages: 5

Pages: 1483-1487

Publication date: 1 May 2019

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Publisher: IEEE

ISBN (Electronic): 9781479981311

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Neuromorphic Hardware, Photonic Neural Networks, Sinusoidal Activations

DOIs:

10.1109/ICASSP.2019.8682218

### **Bibliographical note**

EXT="Tefas, Anastasios"

Source: Scopus

Source ID: 85064389224

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Automatic detection of water inside concrete slabs using ground penetrating radar**

Ground Penetrating Radar (GPR) is generally used as a non-destructive method of inspection for structures and for finding defects in concrete slabs. In this paper, GPR is used in the detection of water inside the cavities of concrete hollow core slabs. We propose an algorithm that determines the water level inside the concrete slab by analyzing the time delays of the reflections originating from inside the cavity. The algorithm is based on utilizing prior knowledge about the geometry of the hollow core slab. The presence of water was successfully detected and an estimate for the height of the water surface was obtained with a GPR system operating with a central frequency of 2.7 GHz. Based on the experiments, the proposed method holds promise in providing a robust and accurate method for the detection of water inside the concrete slabs. Results, possible future research and analysis of the feasibility of GPR systems in water detection are presented and discussed.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences, Research group: MMDM

Contributors: Khan, M. A., Vehmas, R., Visa, A.

Publication date: 1 Apr 2019

### **Host publication information**

Title of host publication: 2019 IEEE Radar Conference, RadarConf 2019

Publisher: IEEE

ISBN (Electronic): 9781728116792

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Instrumentation

DOIs:

10.1109/RADAR.2019.8835797

### **Bibliographical note**

jufoid=57477

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Exploiting Multipath Terahertz Communications for Physical Layer Security in beyond 5G Networks**

Terahertz (THz) band communications, capable of achieving the theoretical capacity of up to several terabits-per-second, are one of the attractive enablers for beyond 5G wireless networks. THz systems will use extremely directional narrow beams, allowing not only to extend the communication range but also to partially secure the data already at the physical layer. The reason is that, in most cases, the Attacker has to be located within the transmitter beam in order to eavesdrop the message. However, even the use of very narrow beams results in the considerably large area around the receiver, where the Attacker can capture all the data. In this paper, we study how to decrease the message eavesdropping probability by leveraging the inherent multi-path nature of the THz communications. We particularly propose sharing the data transmission over multiple THz propagation paths currently available between the communicating entities. We show that, at a cost of the slightly reduced link capacity, the message eavesdropping probability in the described scheme decreases significantly even when several Attackers operate in a cooperative manner. The proposed solution can be utilized for the transmission of the sensitive data, as well as to secure the key exchange in THz band networks beyond 5G.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Research group: Wireless Communications and Positioning, State University of New York

Contributors: Petrov, V., Moltchanov, D., Jornet, J. M., Koucheryavy, Y.

Number of pages: 8

Pages: 865-872

Publication date: 1 Apr 2019

### **Host publication information**

Title of host publication: INFOCOM 2019 - IEEE Conference on Computer Communications Workshops, INFOCOM WKSHPs 2019

Publisher: IEEE

ISBN (Electronic): 9781728118789

ASJC Scopus subject areas: Hardware and Architecture, Signal Processing, Information Systems and Management, Safety, Risk, Reliability and Quality, Computer Networks and Communications  
Electronic versions:

Exploiting Multipath Terahertz Communications 2019

DOIs:

10.1109/INFCOMW.2019.8845312

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002031781>

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Improved Session Continuity in 5G NR with Joint Use of Multi-Connectivity and Guard Bandwidth**

The intermittent millimeter-wave radio links as a result of human-body blockage are an inherent feature of the 5G New Radio (NR) technology by 3GPP. To improve session continuity in these emerging systems, two mechanisms have recently been proposed, namely, multi-connectivity and guard bandwidth. The former allows to establish multiple spatially-diverse connections and switch between them dynamically, while the latter reserves a fraction of system bandwidth for sessions changing their state from non-blocked to blocked, which ensures that the ongoing sessions have priority over the new ones. In this paper, we assess the joint performance of these two schemes for the user- and system-centric metrics of interest. Our numerical results reveal that the multi-connectivity operation alone may not suffice to increase the ongoing session drop probability considerably. On the other hand, the use of guard bandwidth significantly improves session continuity by somewhat compromising new session drop probability and system resource utilization. Surprisingly, the 5G NR system implementing both these techniques inherits their drawbacks. However, complementing it with an initial AP selection procedure effectively alleviates these limitations by maximizing the system resource utilization, while still providing sufficient flexibility to enable the desired trade-off between new and ongoing session drop probabilities.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electrical Engineering, Department of Chemistry and Bioengineering, Peoples' Friendship University of Russia

Contributors: Kovalchukov, R., Moltchanov, D., Begishev, V., Samuylov, A., Andreev, S., Koucheryavy, Y., Samouylov, K.

Publication date: 20 Feb 2019

#### **Host publication information**

Title of host publication: 2018 IEEE Global Communications Conference, GLOBECOM 2018

Publisher: IEEE

ISBN (Electronic): 9781538647271

ASJC Scopus subject areas: Information Systems and Management, Renewable Energy, Sustainability and the Environment, Safety, Risk, Reliability and Quality, Signal Processing, Modelling and Simulation, Instrumentation, Computer Networks and Communications

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10.1109/GLOCOM.2018.8647608

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202001281600>

Source: Scopus

Source ID: 85063532495

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Energy Detection-Based Spectrum Sensing over Fisher-Snedecor F Fading Channels**

This paper investigates the performance of energy detection-based spectrum sensing over Fisher-Snedecor F fading channels. To this end, an analytical expression for the corresponding average detection probability is firstly derived and then this is extended to account for collaborative spectrum sensing. The complementary receiver operating characteristics (ROC) are analyzed for different conditions of the average signal-to-noise ratio (SNR), time-bandwidth product, multipath fading, shadowing and number of collaborating users. It is shown that the energy detection performance is strongly linked to the severity of the multipath fading and amount of shadowing, whereby even small variations in either of these physical phenomena significantly impact the detection probability. Also, the versatile modeling capability of the Fisher-Snedecor F distribution is verified in the context of energy detection based spectrum sensing as it provides considerably more accurate characterization than the conventional Rayleigh fading model. To confirm the validity of the analytical results presented in this paper, we compare them with the results of some simulations.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Research group: Wireless Communications and Positioning, Electrical Engineering, Queen's University, Belfast, Northern Ireland, Centre for Wireless Innovation, Khalifa University, Department of Chemistry and Bioengineering, University of Surrey, German Jordanian University, Aristotle University of Thessaloniki

Contributors: Yoo, S. K., Cotton, S. L., Sofotasios, P. C., Muhaidat, S., Badarneh, O. S., Karagiannidis, G. K.

Publication date: 20 Feb 2019

### Host publication information

Title of host publication: 2018 IEEE Global Communications Conference

Publisher: IEEE

Article number: 8647778

ISBN (Electronic): 9781538647271

ASJC Scopus subject areas: Information Systems and Management, Renewable Energy, Sustainability and the Environment, Safety, Risk, Reliability and Quality, Signal Processing, Modelling and Simulation, Instrumentation, Computer Networks and Communications

DOIs:

10.1109/GLOCOM.2018.8647778

Source: Scopus

Source ID: 85063500863

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### The Direction Cosine Matrix Algorithm in Fixed-point: Implementation and Analysis

Inertial navigation allows tracking and updating the position and orientation of a moving object based on accelerometer and gyroscope data without external positioning aid, such as GPS. Therefore, inertial navigation is an essential technique for, e.g., indoor positioning. As inertial navigation is based on integration of acceleration vector components, computation errors accumulate and make the position and orientation estimate drift. Even though maximum computation precision is desired, also efficiency needs consideration in the age of Internet-of-Things, to enable deployment of inertial navigation based applications to the smallest devices. This work formulates the Direction Cosine Matrix update algorithm, a central component for inertial navigation, in fixed-point and analyzes its precision and computation load compared to a regular floating-point implementation. The results show that the fixed-point version maintains very high precision, while requiring no floating point hardware for operation. The paper presents execution time results on three very different embedded processors.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Computing Sciences

Contributors: Meirhaeghe, A., Boutellier, J., Collin, J.

Publication date: 2019

### Host publication information

Title of host publication: ICASSP 2019 - 2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)

Publisher: IEEE

ISBN (Print): 978-1-4799-8132-8

ISBN (Electronic): 978-1-4799-8131-1

ASJC Scopus subject areas: Signal Processing

DOIs:

10.1109/ICASSP.2019.8683644

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Efficient Solving of Markov Decision Processes on GPUs Using Parallelized Sparse Matrices

Markov Decision Processes (MDPs) provide important capabilities for facilitating the dynamic adaptation of hardware and software configurations to the environments in which they operate. However, the use of MDPs in embedded signal processing systems is limited because of the large computational demands for solving this class of system models. This paper presents Sparse Parallel Value Iteration (SPVI), a new algorithm for solving large MDPs on resource-constrained embedded systems that are equipped with mobile GPUs. SPVI leverages recent advances in parallel solving of MDPs and adds sparse linear algebra techniques to significantly outperform the state-of-the-art. The method and its application are described in detail, and demonstrated with case studies that are implemented on an NVIDIA Tegra K1 System On Chip (SoC). The experimental results show execution time improvements in the range of 65 % -78% for several applications. SPVI also lifts restrictions required by other MDP solver approaches, making it more widely compatible with large classes of optimization problems.

### General information



Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Research area: Computer engineering, Computing Sciences, University of Maryland, Department of Electrical and Computer Engineering, Georgia Institute of Technology

Contributors: Sapio, A., Bhattacharyya, S. S., Wolf, M.

Number of pages: 6

Pages: 13-18

Publication date: Dec 2018

### Host publication information

Title of host publication: 2018 Conference on Design and Architectures for Signal and Image Processing, DASIP 2018

Publisher: IEEE COMPUTER SOCIETY PRESS

ISBN (Electronic): 9781538682371

### Publication series

Name: Conference on Design and Architectures for Signal and Image Processing, DASIP

ISSN (Print): 2164-9766

ASJC Scopus subject areas: Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: CUDA, GPU, Markov decision processes, MDP, Sparsity, Value iteration

DOIs:

10.1109/DASIP.2018.8596969

### Bibliographical note

jufoid=71852

Source: Scopus

Source ID: 85061388518

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### An active learning method using clustering and committee-based sample selection for sound event classification

This paper proposes an active learning method to control a labeling process for efficient annotation of acoustic training material, which is used for training sound event classifiers. The proposed method performs K-medoids clustering over an initially unlabeled dataset, and medoids as local representatives, are presented to an annotator for manual annotation. The annotated label on a medoid propagates to other samples in its cluster for label prediction. After annotating the medoids, the annotation continues to the unexamined sounds with mismatched prediction results from two classifiers, a nearest-neighbor classifier and a model-based classifier, both trained with annotated data. The annotation on the segments with mismatched predictions are ordered by the distance to the nearest annotated sample, farthest first. The evaluation is made on a public environmental sound dataset. The labels obtained through a labeling process controlled by the proposed method are used to train a classifier, using supervised learning. Only 20% of the data needs to be manually annotated with the proposed method, to achieve the accuracy with all the data annotated. In addition, the proposed method clearly outperforms other active learning algorithms proposed for sound event classification through all the experiments, simulating varying fraction of data that is manually labeled.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Audio research group - ARG

Contributors: Shuyang, Z., Heittola, T., Virtanen, T.

Number of pages: 5

Pages: 116-120

Publication date: 2 Nov 2018

### Host publication information

Title of host publication: 16th International Workshop on Acoustic Signal Enhancement, IWAENC 2018

Publisher: IEEE

ISBN (Electronic): 9781538681510

ASJC Scopus subject areas: Signal Processing, Acoustics and Ultrasonics

Keywords: Active learning, Committee-based sample selection, K-medoids clustering, Sound event classification

Electronic versions:

MAL2

DOIs:

10.1109/IWAENC.2018.8521336

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202001161336>

Source: Scopus

Source ID: 85057424847

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Using sequential information in polyphonic sound event detection

To detect the class, and start and end times of sound events in real world recordings is a challenging task. Current computer systems often show relatively high frame-wise accuracy but low event-wise accuracy. In this paper, we attempted to merge the gap by explicitly including sequential information to improve the performance of a state-of-the-art polyphonic sound event detection system. We propose to 1) use delayed predictions of event activities as additional input features that are fed back to the neural network; 2) build N-grams to model the co-occurrence probabilities of different events; 3) use se-quentialloss to train neural networks. Our experiments on a corpus of real world recordings show that the N-grams could smooth the spiky output of a state-of-the-art neural network system, and improve both the frame-wise and the event-wise metrics.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Audio research group - ARG

Contributors: Huang, G., Heittola, T., Virtanen, T.

Number of pages: 5

Pages: 291-295

Publication date: 2 Nov 2018

#### Host publication information

Title of host publication: 16th International Workshop on Acoustic Signal Enhancement, IWAENC 2018

Publisher: IEEE

ISBN (Electronic): 9781538681510

ASJC Scopus subject areas: Signal Processing, Acoustics and Ultrasonics

Keywords: Language modelling, Polyphonic sound event detection, Sequential information

Electronic versions:

Using sequential information in polyphonic 2018

DOIs:

10.1109/IWAENC.2018.8521367

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202003042529>

Source: Scopus

Source ID: 85057368244

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Acoustic scene classification: An overview of dcase 2017 challenge entries

We present an overview of the challenge entries for the Acoustic Scene Classification task of DCASE 2017 Challenge. Being the most popular task of the challenge, acoustic scene classification entries provide a wide variety of approaches for comparison, with a wide performance gap from top to bottom. Analysis of the submissions confirms once more the popularity of deep-learning approaches and mel frequency representations. Statistical analysis indicates that the top ranked system performed significantly better than the others, and that combinations of top systems are capable of reaching close to perfect performance on the given data.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Audio research group - ARG

Contributors: Mesaros, A., Heittola, T., Virtanen, T.

Number of pages: 5

Pages: 411-415

Publication date: 2 Nov 2018

#### Host publication information

Title of host publication: 16th International Workshop on Acoustic Signal Enhancement, IWAENC 2018

Publisher: IEEE

ISBN (Electronic): 9781538681510

ASJC Scopus subject areas: Signal Processing, Acoustics and Ultrasonics

Keywords: Acoustic scene classification, Audio classification, DCASE challenge

DOIs:

10.1109/IWAENC.2018.8521242

Source: Scopus

Source ID: 85057432865

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Time-frequency masking strategies for single-channel low-latency speech enhancement using neural networks**

This paper presents a low-latency neural network based speech enhancement system. Low-latency operation is critical for speech communication applications. The system uses the time-frequency (TF) masking approach to retain speech and remove the non-speech content from the observed signal. The ideal TF mask are obtained by supervised training of neural networks. As the main contribution different neural network models are experimentally compared to investigate computational complexity and speech enhancement performance. The proposed system is trained and tested on noisy speech data where signal-to-noise ratio (SNR) ranges from -5 dB to +5 dB and the results show significant reduction of non-speech content in the resulting signal while still meeting a low-latency operation criterion, which is here considered to be less than 20 ms.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Audio research group - ARG, Huawei European Research Center

Contributors: Parviainen, M., Pertila, P., Virtanen, T., Grosche, P.

Number of pages: 5

Pages: 51-55

Publication date: 2 Nov 2018

#### **Host publication information**

Title of host publication: 16th International Workshop on Acoustic Signal Enhancement, IWAENC 2018

Publisher: IEEE

ISBN (Electronic): 9781538681510

ASJC Scopus subject areas: Signal Processing, Acoustics and Ultrasonics

Keywords: Neural networks, Speech enhancement

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time-frequency\_masking\_strategies

DOIs:

10.1109/IWAENC.2018.8521400

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202001161338>

Source: Scopus

Source ID: 85057354159

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Deep neural network based speech separation optimizing an objective estimator of intelligibility for low latency applications**

Mean square error (MSE) has been the preferred choice as loss function in the current deep neural network (DNN) based speech separation techniques. In this paper, we propose a new cost function with the aim of optimizing the extended short time objective intelligibility (ESTOI) measure. We focus on applications where low algorithmic latency ( $\leq 10$  ms) is important. We use long short-term memory networks (LSTM) and evaluate our proposed approach on four sets of two-speaker mixtures from extended Danish hearing in noise (HINT) dataset. We show that the proposed loss function can offer improved or at par objective intelligibility (in terms of ESTOI) compared to an MSE optimized baseline while resulting in lower objective separation performance (in terms of the source to distortion ratio (SDR)). We then proceed to propose an approach where the network is first initialized with weights optimized for MSE criterion and then trained with the proposed ESTOI loss criterion. This approach mitigates some of the losses in objective separation performance while preserving the gains in objective intelligibility.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Audio research group - ARG, Oticon A/S

Contributors: Naithani, G., Nikunen, J., Bramslov, L., Virtanen, T.

Number of pages: 5

Pages: 386-390

Publication date: 2 Nov 2018

#### **Host publication information**

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Publisher: IEEE

ISBN (Electronic): 9781538681510

ASJC Scopus subject areas: Signal Processing, Acoustics and Ultrasonics  
Keywords: Deep neural networks, Low latency, Speech intelligibility, Speech separation  
DOIs:

10.1109/IWAENC.2018.8521379

Source: Scopus

Source ID: 85057383332

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Multichannel NMF for source separation with ambisonic signals**

This paper proposes a novel method for separation of sound sources with ambisonic signals using multichannel non-negative matrix factorization (MNMF) for source spectrogram estimation. We present a novel frequency-independent spatial covariance matrix (SCM) model for spherical harmonic (SH) domain signals which makes the MNMF parameter estimation framework computationally feasible up to 3rd order SH signals. The evaluation is done with simulated SH domain mixtures by measuring the separation performance using objective criteria and comparing the proposed method against SH domain beamforming. The proposed method improves average separation performance over beamforming with post-filtering when using 1st and 2nd order SH signals while at higher orders performance among all tested methods is similar.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Aalto University

Contributors: Nikunen, J., Politis, A.

Number of pages: 5

Pages: 251-255

Publication date: 2 Nov 2018

### **Host publication information**

Title of host publication: 16th International Workshop on Acoustic Signal Enhancement, IWAENC 2018

Publisher: IEEE

ISBN (Electronic): 9781538681510

ASJC Scopus subject areas: Signal Processing, Acoustics and Ultrasonics

Keywords: Ambisonics, Multichannel NMF, Source separation

DOIs:

10.1109/IWAENC.2018.8521344

Source: Scopus

Source ID: 85057417393

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Identification of Parkinson's Disease Utilizing a Single Self-recorded 20-step Walking Test Acquired by Smartphone's Inertial Measurement Unit**

Parkinson's disease (PD) is a degenerative and long-term disorder of the central nervous system, which often causes motor symptoms, e.g., tremor, rigidity, and slowness. Currently, the diagnosis of PD is based on patient history and clinical examination. Technology-derived decision support systems utilizing, for example, sensor-rich smartphones can facilitate more accurate PD diagnosis. These technologies could provide less obtrusive and more comfortable remote symptom monitoring. The recent studies showed that motor symptoms of PD can reliably be detected from data gathered via smartphones. The current study utilized an open-access dataset named 'mPower' to assess the feasibility of discriminating PD from non-PD by analyzing a single self-administered 20-step walking test. From this dataset, 1237 subjects (616 had PD) who were age and gender matched were selected and classified into PD and non-PD categories. Linear acceleration (ACC) and gyroscope (GYRO) were recorded by built-in sensors of smartphones. Walking bouts were extracted by thresholding signal magnitude area of the ACC signals. Features were computed from both ACC and GYRO signals and fed into a random forest classifier of size 128 trees. The classifier was evaluated deploying 100-fold cross-validation and provided an accumulated accuracy rate of 0.7 after 10k validations. The results show that PD and non-PD patients can be separated based on a single short-lasting self-administered walking test gathered by smartphones' built-in inertial measurement units.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Faculty of Biomedical Sciences and Engineering, Research group: Personal Health Informatics-PHI, Unit of Neurology, Satakunta Central Hospital

Contributors: Mehrang, S., Jauhiainen, M., Pietilä, J., Puustinen, J., Ruokolainen, J., Nieminen, H.

Number of pages: 4

Pages: 2913-2916

Publication date: 26 Oct 2018

#### Host publication information

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Volume: 2018-July

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 8512921

ISBN (Electronic): 9781538636466

ASJC Scopus subject areas: Signal Processing, Biomedical Engineering, Computer Vision and Pattern Recognition, Health Informatics

DOIs:

10.1109/EMBC.2018.8512921

Source: Scopus

Source ID: 85056600537

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Eigen Posture Based Fall Risk Assessment System Using Kinect

Postural Instability (PI) is a major reason for fall in geriatric population as well as for people with diseases or disorders like Parkinson's, stroke etc. Conventional stability indicators like Berg Balance Scale (BBS) require clinical settings with skilled personnel's interventions to detect PI and finally classify the person into low, mid or high fall risk categories. Moreover these tests demand a number of functional tasks to be performed by the patient for proper assessment. In this paper a machine learning based approach is developed to determine fall risk with minimal human intervention using only Single Limb Stance exercise. The analysis is done based on the spatiotemporal dynamics of skeleton joint positions obtained from Kinect sensor. A novel posture modeling method has been applied for feature extraction along with some traditional time domain and metadata features to successfully predict the fall risk category. The proposed unobtrusive, affordable system is tested over 224 subjects and is able to achieve 75% mean accuracy on the geriatric and patient population.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Tata Consultancy Services India

Contributors: Tripathy, S. R., Chakravarty, K., Sinha, A.

Number of pages: 4

Pages: 1-4

Publication date: 26 Oct 2018

#### Host publication information

Title of host publication: 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC 2018

Volume: 2018-July

Publisher: IEEE

Article number: 8513263

ISBN (Electronic): 9781538636466

ASJC Scopus subject areas: Signal Processing, Biomedical Engineering, Computer Vision and Pattern Recognition, Health Informatics

Keywords: BBS, Eigenpose, EMD, Fall risk, Index Terms-Kinect

DOIs:

10.1109/EMBC.2018.8513263

Source: Scopus

Source ID: 85056666030

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### The Accuracy of Atrial Fibrillation Detection from Wrist Photoplethysmography. A Study on Post-Operative Patients

Atrial fibrillation (AF) is the most common type of cardiac arrhythmia. Although not life-threatening itself, AF significantly increases the risk of stroke and myocardial infarction. Current tools available for screening and monitoring of AF are inadequate and an unobtrusive alternative, suitable for long-term use, is needed. This paper evaluates an atrial fibrillation detection algorithm based on wrist photoplethysmographic (PPG) signals. 29 patients recovering from surgery in the post-anesthesia care unit were monitored. 15 patients had sinus rhythm (SR, 67.5± 10.7 years old, 7 female) and 14 patients had AF (74.8± 8.3 years old, 8 female) during the recordings. Inter-beat intervals (IBI) were estimated from PPG signals. As IBI estimation is highly sensitive to motion or other types of noise, acceleration signals and PPG waveforms were used to automatically detect and discard unreliable IBI. AF was detected from windows of 20 consecutive IBI with 98.45±6.89% sensitivity and 99.13±1.79% specificity for 76.34±19.54% of the time. For the remaining time, no decision was taken due to the lack of reliable IBI. The results show that wrist PPG is suitable for long term monitoring and AF screening. In addition, this technique provides a more comfortable alternative to ECG devices.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Faculty of Biomedical Sciences and Engineering, Research group: Sensor Technology and Biomeasurements (STB), PulseOn SA, Tampere University Hospital

Contributors: Tarniceriu, A., Harju, J., Yousefi, Z. R., Vehkaoja, A., Parak, J., Yli-Hankala, A., Korhonen, I.

Number of pages: 4

Pages: 4844-4847

Publication date: 26 Oct 2018

### Host publication information

Title of host publication: 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC 2018

Volume: 2018-July

Publisher: IEEE

Article number: 8513197

ISBN (Electronic): 9781538636466

ASJC Scopus subject areas: Signal Processing, Biomedical Engineering, Computer Vision and Pattern Recognition, Health Informatics

Electronic versions:

The Accuracy of Atrial Fibrillation Detection from Wrist Photoplethysmography. A study on Post-Operative Patients  
DOIs:

10.1109/EMBC.2018.8513197

URLs:

<http://urn.fi/URN:NBN:fi:tty-201902051214>

### Bibliographical note

INT=tut-bmt, "Yousefi, Zeinab Rezaei"

Source: Scopus

Source ID: 85056672654

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### LoTTA: Energy-Efficient Processor for Always-on Applications

Various use cases in the era of Internet-of-Things (IoT) demand processor devices to have low energy consumption in order to maximize the battery life. In addition to energy constraints, there is often a need to both swiftly execute control-oriented code to provide low reaction times and to occasionally perform real time signal processing tasks efficiently. As a response to these requirements, we propose LoTTA, an extremely energy-efficient exposed datapath core. Its transport-triggered programming model helps in lowering the execution latency via low cost data forwarding. Control efficiency is achieved by an optimized control unit with zero delay slot branches and predicated execution. An instruction register file is included for frequently executed program hot spots to reduce the instruction stream energy consumption. These features allow the processor to execute CHStone and EEMBC CoreMark benchmarks on average with 19% fewer cycles compared to a 6-stage LM32, a traditional RISC core with similar datapath resources. The core consumes 53% less energy on average compared to the RISC core. When including the instruction stream overheads, in the best case, LoTTA saves 79% energy, and on average 40%.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, Research area: Computer engineering

Contributors: Multanen, J., Kultala, H., Jääskeläinen, P., Viitanen, T., Tervo, A., Takala, J.

Publication date: Oct 2018

### Host publication information

Title of host publication: 2018 IEEE International Workshop on Signal Processing Systems (SiPS)

Publisher: IEEE

ISBN (Print): 978-1-5386-6319-6

ISBN (Electronic): 978-1-5386-6318-9

ASJC Scopus subject areas: Computer Science(all), Hardware and Architecture, Signal Processing

Keywords: Energy efficiency, low power, Computer architecture, IoT, always-on, Processor

Electronic versions:

LoTTA: Energy-Efficient Processor 2018

DOIs:

10.1109/SiPS.2018.8598408

URLs:

### **Estimation of time-varying room impulse responses of multiple sound sources from observed mixture and isolated source signals**

This paper proposes a method for online estimation of time-varying room impulse responses (RIR) between multiple isolated sound sources and a far-field mixture. The algorithm is formulated as adaptive convolutive filtering in short-time Fourier transform (STFT) domain. We use the recursive least squares (RLS) algorithm for estimating the filter parameters due to its fast convergence rate, which is required for modeling rapidly changing RIRs of moving sound sources. The proposed method allows separation of reverberated sources from the far-field mixture given that their close-field signals are available. The evaluation is based on measuring unmixing performance (removal of reverberated source) using objective separation criteria calculated between the ground truth recording of the preserved sources and the unmixing result obtained with the proposed algorithm. We compare online and offline formulations for the RIR estimation and also provide evaluation with blind source separation algorithm only operating on the mixture signal.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Audio research group - ARG

Contributors: Nikunen, J., Virtanen, T.

Number of pages: 5

Pages: 421-425

Publication date: 10 Sep 2018

#### **Host publication information**

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Volume: 2018-April

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 8462535

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#### **Publication series**

Name: Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing

ISSN (Electronic): 2379-190X

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Adaptive filtering, Informed source separation, Online room impulse response estimation, Source unmixing

DOIs:

10.1109/ICASSP.2018.8462535

#### **Bibliographical note**

jufoid=57409

Source: Scopus

Source ID: 85054234348

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Low-energy graph fourier basis functions span salient objects**

There is an emerging interest aiming at defining principles for signals on general graphs, which are analogous to the basic principles in traditional signal processing. One example is the Graph Fourier Transform which aims at decomposing a graph signal into its components based on a set of basis functions with corresponding graph frequencies. It has been observed that most of the important information of a graph signal is contained inside the low frequency band, which leads to several applications such as denoising, compression, etc. In this paper, we show that the low frequency basis functions span the salient regions in an image, which can also be considered as important regions. Motivated by this, we present a novel simple and unsupervised method to utilize a number of low-energy basis functions and show that it improves the performance of seven state-of-the-art salient object detection methods in five datasets under four different evaluation criteria, with only minor exceptions.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Multimedia Research Group - MRG

Contributors: Malik, J., Aytakin, C., Gabbouj, M.

Number of pages: 5

Pages: 1548-1552

Publication date: 10 Sep 2018

### Host publication information

Title of host publication: 2018 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2018 - Proceedings

Volume: 2018-April

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 8462672

ISBN (Print): 9781538646588

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Graph fourier transform, Graph signal processing, Salient object detection

DOIs:

10.1109/ICASSP.2018.8462672

### Bibliographical note

jufoid=57409

Source: Scopus

Source ID: 85054244934

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Statistical Evaluation of Visual Quality Metrics for Image Denoising

This paper studies the problem of full reference visual quality assessment of denoised images with a special emphasis on images with low contrast and noise-like texture. Denoising of such images together with noise removal often results in image details loss or smoothing. A new test image database, FLT, containing 75 noise-free 'reference' images and 300 filtered ('distorted') images is developed. Each reference image, corrupted by an additive white Gaussian noise, is denoised by the BM3D filter with four different values of threshold parameter (four levels of noise suppression). After carrying out a perceptual quality assessment of distorted images, the mean opinion scores (MOS) are obtained and compared with the values of known full reference quality metrics. As a result, the Spearman Rank Order Correlation Coefficient (SROCC) between PSNR values and MOS has a value close to zero, and SROCC between values of known full-reference image visual quality metrics and MOS does not exceed 0.82 (which is reached by a new visual quality metric proposed in this paper). The FLT dataset is more complex than earlier datasets used for assessment of visual quality for image denoising. Thus, it can be effectively used to design new image visual quality metrics for image denoising.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Computational Imaging-CI, National Aerospace University

Contributors: Egiazarian, K., Ponomarenko, M., Lukin, V., Ieremeiev, O.

Number of pages: 5

Pages: 6752-6756

Publication date: 10 Sep 2018

### Host publication information

Title of host publication: 2018 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2018 - Proceedings

Volume: 2018-April

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 8462294

ISBN (Print): 9781538646588

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: BM3D, Full-reference metrics, Image denoising, Image visual quality assessment

DOIs:

10.1109/ICASSP.2018.8462294

### Bibliographical note

EXT="Lukin, Vladimir"

JUFOID=57409

Source: Scopus

Source ID: 85054084165

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### A joint target localization and classification framework for sensor networks

In this paper, we propose a joint framework for target localization and classification using a single generalized model for non-imaging based multi-modal sensor data. For target localization, we exploit both sensor data and estimated dynamics within a local neighborhood. We validate the capabilities of our framework by using a multi-modal dataset, which includes ground truth GPS information (e.g., time and position) and data from co-located seismic and acoustic sensors. Experimental results show that our framework achieves better classification accuracy compared to recent fusion



algorithms using temporal accumulation and achieves more accurate target localizations than multilateration.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, Research area: Computer engineering, U.S. Army Research Laboratory, University of Maryland

Contributors: Lee, K., Riggan, B. S., Bhattacharyya, S. S.

Number of pages: 5

Pages: 3076-3080

Publication date: 10 Sep 2018

#### Host publication information

Title of host publication: 2018 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2018 - Proceedings

Volume: 2018-April

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 8462641

ISBN (Print): 9781538646588

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Classification, Localization, Sensor fusion, Sensor networks, Tracking

DOIs:

10.1109/ICASSP.2018.8462641

#### Bibliographical note

JUFID=57409

Source: Scopus

Source ID: 85054211699

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### 2D Video Coding of Volumetric Video Data

Due to the increased popularity of augmented and virtual reality experiences, the interest in representing the real world in an immersive fashion has never been higher. Distributing such representations enables users all over the world to freely navigate in never seen before media experiences. Unfortunately, such representations require a large amount of data, not feasible for transmission on today's networks. Thus, efficient compression technologies are in high demand. This paper proposes an approach to compress 3D video data utilizing 2D video coding technology. The proposed solution was developed to address the needs of 'tele-immersive' applications, such as virtual (VR), augmented (AR) or mixed (MR) reality with Six Degrees of Freedom (6DoF) capabilities. Volumetric video data is projected on 2D image planes and compressed using standard 2D video coding solutions. A key benefit of this approach is its compatibility with readily available 2D video coding infrastructure. Furthermore, objective and subjective evaluation shows significant improvement in coding efficiency over reference technology.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Nokia Technologies

Contributors: Schwarz, S., Hannuksela, M. M., Fakour-Sevom, V., Sheikhi-Pour, N.

Number of pages: 5

Pages: 61-65

Publication date: 5 Sep 2018

#### Host publication information

Title of host publication: 2018 Picture Coding Symposium, PCS 2018 - Proceedings

Publisher: IEEE

Article number: 8456265

ISBN (Print): 9781538641606

ASJC Scopus subject areas: Signal Processing, Media Technology

DOIs:

10.1109/PCS.2018.8456265

#### Bibliographical note

INT=sgn,"Sheikhi-Pour, Nahid"

Source: Scopus

Source ID: 85053915056

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **User Positioning in mmW 5G Networks Using Beam-RSRP Measurements and Kalman Filtering**

In this paper, we exploit the 3D-beamforming features of multiantenna equipment employed in fifth generation (5G) networks, operating in the millimeter wave (mmW) band, for accurate positioning and tracking of users. We consider sequential estimation of users' positions, and propose a two-stage extended Kalman filter (EKF) that is based on reference signal received power (RSRP) measurements. In particular, beamformed downlink (DL) reference signals (RSs) are transmitted by multiple base stations (BSs) and measured by user equipments (UEs) employing receive beamforming. The so-obtained beam-RSRP (BRSRP) measurements are reported to the BSs where the corresponding directions of departure (DoDs) are sequentially estimated by a novel EKF. Such angle estimates from multiple BSs are subsequently fused on a central entity into 3D position estimates of UEs by means of another (second-stage) EKF. The proposed positioning scheme is scalable since the computational burden is shared among different network entities, namely transmission/reception points (TRPs) and 5G-NR Node B (gNB), and may be accomplished with the signalling currently specified for 5G. We assess the performance of the proposed algorithm on a realistic outdoor 5G deployment with a detailed ray tracing propagation model based on the METIS Madrid map. Numerical results with a system operating at 39 GHz show that sub-meter 3D positioning accuracy is achievable in future mmW 5G networks.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Huawei Technologies Oy (Finland) Co., Ltd

Contributors: Rastorgueva-Foi, E., Costa, M., Koivisto, M., Leppänen, K., Valkama, M.

Number of pages: 7

Pages: 1150-1156

Publication date: 5 Sep 2018

#### **Host publication information**

Title of host publication: 2018 21st International Conference on Information Fusion, FUSION 2018

Publisher: IEEE

Article number: 8455289

ISBN (Print): 978-1-5386-4330-3

ISBN (Electronic): 978-0-9964527-6-2

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Signal Processing, Statistics, Probability and Uncertainty, Instrumentation

Keywords: 5G networks, beamforming, direction-of-departure, extended Kalman filter, line-of-sight, localization, location-awareness, positioning, RSRP, tracking

Electronic versions:

User Positioning in mmW 5G Networks 2018

DOIs:

10.23919/ICIF.2018.8455289

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002262360>

Source: Scopus

Source ID: 85054063725

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Inertial Odometry on Handheld Smartphones**

Building a complete inertial navigation system using the limited quality data provided by current smartphones has been regarded challenging, if not impossible. This paper shows that by careful crafting and accounting for the weak information in the sensor samples, smartphones are capable of pure inertial navigation. We present a probabilistic approach for orientation and use-case free inertial odometry, which is based on double-integrating rotated accelerations. The strength of the model is in learning additive and multiplicative IMU biases online. We are able to track the phone position, velocity, and pose in realtime and in a computationally lightweight fashion by solving the inference with an extended Kalman filter. The information fusion is completed with zero-velocity updates (if the phone remains stationary), altitude correction from barometric pressure readings (if available), and pseudo-updates constraining the momentary speed. We demonstrate our approach using an iPad and iPhone in several indoor dead-reckoning applications and in a measurement tool setup.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Artificial Intelligence and Vision - AIV, Aalto University

Contributors: Solin, A., Cortes, S., Rahtu, E., Kannala, J.

Number of pages: 8

Pages: 1361-1368

Publication date: 5 Sep 2018

### Host publication information

Title of host publication: 2018 21st International Conference on Information Fusion, FUSION 2018

Publisher: IEEE

Article number: 8455482

ISBN (Print): 9780996452762

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Signal Processing, Statistics, Probability and Uncertainty, Instrumentation

DOIs:

10.23919/ICIF.2018.8455482

Source: Scopus

Source ID: 85054102788

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Multi-source localization using a DOA Kernel based spatial covariance model and complex nonnegative matrix factorization

This paper presents an algorithm for multiple source localization using a beamforming-inspired spatial covariance model (SCM) and complex non-negative matrix factorization (CNMF). In this work, we assume that the source signals are known in advance whereas the mixing filter is modeled by the weighted sum of direction of arrival (DOA) kernels which encode the phase and the amplitude differences between microphones for every possible source direction. The direction of arrival (i.e. azimuth and elevation) for each source is estimated using CNMF. The proposed system is evaluated for DOA estimation task using two datasets covering a large number of configurations (number of channels, number of simultaneous sources, reverberation time, microphones spacing, source types and angular positions of the sources). Finally, a comparison to other state-of-the-art methods is performed, showing the robustness of the proposed method.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Audio research group - ARG, Universidad de Jaen

Contributors: Carabias-Orti, J. J., Cabanas-Molero, P., Vera-Candeas, P., Nikunen, J.

Number of pages: 5

Pages: 440-444

Publication date: 27 Aug 2018

### Host publication information

Title of host publication: 2018 IEEE 10th Sensor Array and Multichannel Signal Processing Workshop, SAM 2018

Publisher: IEEE

Article number: 8448664

ISBN (Print): 9781538647523

### Publication series

Name: Proceedings of the IEEE Sensor Array and Multichannel Signal Processing Workshop

ISSN (Print): 1551-2282

ISSN (Electronic): 2151-870X

ASJC Scopus subject areas: Signal Processing, Control and Systems Engineering, Electrical and Electronic Engineering

Keywords: Direction of arrival, Nonnegative matrix factorization, Source localization, Spatial covariance matrix, Time difference of arrival

DOIs:

10.1109/SAM.2018.8448664

### Bibliographical note

EXT="Carabias-Orti, J. J."

Source: Scopus

Source ID: 85053623218

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Anisotropic Spatiotemporal Regularization in Compressive Video Recovery by Adaptively Modeling the Residual Errors as Correlated Noise

Many approaches to compressive video recovery proceed iteratively, treating the difference between the previous estimate and the ideal video as residual noise to be filtered. We go beyond the common white-noise modeling by adaptively modeling the residual as stationary spatiotemporally correlated noise. This adaptive noise model is updated at each iteration and is highly anisotropic in space and time; we leverage it with respect to the transform spectra of a motion-compensated video denoiser. Experimental results demonstrate that our proposed adaptive correlated noise model outperforms state-of-the-art methods both quantitatively and qualitatively.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Signal and Image Restoration-RST

Contributors: Eslahi, N., Foi, A.

Publication date: 27 Aug 2018

### Host publication information

Title of host publication: 2018 IEEE 13th Image, Video, and Multidimensional Signal Processing Workshop, IVMSP 2018 - Proceedings

Publisher: IEEE

Article number: 8448455

ISBN (Print): 9781538609514

ASJC Scopus subject areas: Signal Processing, Media Technology

Electronic versions:

IVMSP2018-Eslahi-Foi

DOIs:

10.1109/IVMSPW.2018.8448455

URLs:

<http://urn.fi/URN:NBN:fi:tty-201810292494>

Source: Scopus

Source ID: 85053868569

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Performance Evaluation of UAV-Assisted mmWave Operation in Mobility-Enabled Urban Deployments

To meet the capacity demand of future cellular networks, which is expected to increase substantially by 2020, using mm Wave band has been suggested. Although this higher frequency band has larger amounts of spectrum and will lead to much higher capacity in 5G networks, it has some propagation constraints such as limited coverage and sensitivity to Line of Sight (LoS) blockage. A possible solution to these issues could be small cell densification combined with utilizing access points carried by Unmanned Aerial Vehicles (UAVs). This paper presents a performance evaluation of the UAV-assisted mmWave network in urban environments using ns-3 simulations.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno

Contributors: Khosravi, Z., Gerasimenko, M., Andreev, S., Koucheryavy, Y.

Number of pages: 4

Pages: 150-153

Publication date: 20 Aug 2018

### Host publication information

Title of host publication: 2018 41st International Conference on Telecommunications and Signal Processing, TSP 2018

Publisher: IEEE

Article number: 8441321

ISBN (Print): 9781538646953

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

Keywords: 5G, drone cell, mm Wave, ns3

DOIs:

10.1109/TSP.2018.8441321

### Bibliographical note

INT=elt,"Khosravi, Zeinab"

Source: Scopus

Source ID: 85053557557

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Data Clustering Based on Community Structure in Mutual k-Nearest Neighbor Graph

Data clustering is a fundamental machine learning problem. Community structure is common in social and biological networks. In this article we propose a novel data clustering algorithm that uses this phenomenon in mutual k - nearest neighbor (MKNN) graph constructed from the input dataset. We use the authentic scores-a metric that measures the strength of an edge in a social network graph-to rank all the edges in the MKNN graph. By removing the edges gradually in the order of their authentic scores, we collapse the MKNN graph into components to find the clusters. The proposed method has two major advantages comparing to other popular data clustering algorithms. First, it is robust to the noise in

the data. Second, it finds clusters of arbitrary shape. We evaluated our algorithm on synthetic noisy datasets, synthetic 2D datasets and real-world image datasets. Results on the noisy datasets show that the proposed algorithm clearly outperforms the competing algorithms in terms of Normalized Mutual Information (NMI) scores. The proposed algorithm is the only one that does not fail on any data in the synthetic 2D dataset, which are specifically designed to show the limitations of the clustering algorithms. When testing on the real-world image datasets, the best NMI scores achieved by the proposed algorithm is more than any other competing algorithm. The proposed algorithm has computational complexity of  $O(k^3n+kn\log(kn))$  and space complexity of  $O(kn)$ , which is better than or equivalent to the most popular clustering algorithms.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Multimedia Research Group - MRG, Qatar University

Contributors: Zhang, H., Kiranyaz, S., Gabbouj, M.

Number of pages: 7

Pages: 262-268

Publication date: 20 Aug 2018

#### Host publication information

Title of host publication: 2018 41st International Conference on Telecommunications and Signal Processing, TSP 2018

Publisher: IEEE

Article number: 8441226

ISBN (Print): 9781538646953

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

Keywords: authentic score, data clustering, graph

DOIs:

10.1109/TSP.2018.8441226

#### Bibliographical note

EXT="Kiranyaz, Serkan"

Source: Scopus

Source ID: 85053518955

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Improvement of GPS and BeiDou extended orbit predictions with CNNs

This paper presents a method for improving the accuracy of extended GNSS satellite orbit predictions with convolutional neural networks (CNN). Satellite orbit predictions are used in self-assisted GNSS to reduce the Time to First Fix of a satellite positioning device. We describe the models we use to predict the satellite orbit and present the improvement method that uses CNN. The CNN estimates future prediction errors of our model and these estimates are used to correct our orbit predictions. We also describe how the neural network can be implemented into our prediction algorithm. In tests with GPS and BeiDou data, the method significantly improves orbit prediction accuracy. For example, the 68% error quantile of 7 day orbit prediction errors of GPS satellites was reduced by 45% on average.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Automation and Hydraulic Engineering, Research group: Automation and Systems Theory, Mathematics,

Research group: Positioning

Contributors: Pihlajassalo, J., Leppäkoski, H., Ali-Löytty, S., Piché, R.

Number of pages: 6

Pages: 54-59

Publication date: 10 Aug 2018

#### Host publication information

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Publisher: IEEE

Article number: 8433244

ISBN (Print): 9781538649626

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Control and Optimization

Electronic versions:

CNN\_paper

DOIs:

10.1109/EURONAV.2018.8433244

URLs:

<http://urn.fi/URN:NBN:fi:tty-201809212324>

### **Bibliographical note**

INT=mat,"Jaakko Pihlajasalo"

Source: Scopus

Source ID: 85052494723

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Role of the user in information systems development**

We have focused our paper on the aspects important in adapting an Information System (IS) to the user's cultural background. We are interested both in the factors related to IS development and in the use of IS. Increasingly, ISs are being developed and used in a global context. We have perceived differences in expectations of functionalities, architecture, structural properties, information search practices, web-based system properties, and user interfaces. One conclusion would be that a high quality IS reflects user behavior in its use context. In that case, the system has to model its user one way or another. Until now, the topic has been handled without meaningful effort to model user behavior. Current publications cover a wide variety of rules on how to take into account cultural differences in the IS context. In this paper, our aim is to study the current state-of-the-art of user modeling - modeling the human being as an IS user. We start with general aspects related to the role of the user in IS development and alternatives to adaptable systems. The findings are applicable in the educational context as well. More and more, the use of computers and ISs is becoming an essential part of studies: the use of MOOCs (Massively Open Online Courses) as a part or replacement for traditional face-to-face classes; flipped learning methodology emphasizing the significance of self-learning; and blended learning, including quite often computerized study content. Our focus is on the global context, in which students represent different cultures and the IS is globally available.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, Research group: Software Engineering and Intelligent Systems, Computer Science Institute, Tallinn University of Technology, University of Lapland

Contributors: Jaakkola, H., Thalheim, B., Henno, J., Mäkelä, J., Keto, H.

Number of pages: 8

Pages: 625-632

Publication date: 28 Jun 2018

### **Host publication information**

Title of host publication: 2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2018

Publisher: IEEE

ISBN (Electronic): 9789532330977

ASJC Scopus subject areas: Electrical and Electronic Engineering, Hardware and Architecture, Signal Processing, Computer Networks and Communications

Keywords: adaption, context, human behavior modeling, information system, information systems development, requirements engineering, user, user adaptable, user modeling

Electronic versions:

2018-Mipro-hj-P4699

DOIs:

10.23919/MIPRO.2018.8400118

URLs:

<http://urn.fi/URN:NBN:fi:tty-201901161102>

Source: Scopus

Source ID: 85050202384

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Adjusting university education with workspace training and self-education**

Close to 100% employment of students and easy access to abundance of information on Internet has essentially changed student's learning practices and their earlier knowledge background, especially on rapidly progressing field of Software Engineering. On workplace they have to use technologies, which are used in practice of their employing enterprise, but often do not understand the scientific and/or technological principles on which these technologies are based. They seek explanations on Internet, but information on Internet is often low quality, one-sided and presented with business targets on mind - to get more users to technologies developed and sold by a business enterprise. Thus university has to explain basic principles of technologies what students already know and have used and correct some popular beliefs, which are supported by software vendors and based their business interests. Non-formal sources of knowledge - workplace training and Internet - do not reduce teacher's task, but force teachers constantly study all new which appears in this field, thus increase teachers workload. Students increasing use of non-formal sources of knowledge imply need for flipping the process - instead of teaching students are set to learn from provided detailed tutorials. Use of Internet and work has made self-study, seeking information from Internet sources very customary for current students, thus such flipping worked very well in a game programming course provided by the first author.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, Research group: Software Engineering and Intelligent Systems, Tallinn University of Technology, University of Lapland

Contributors: Henno, J., Jaakkola, H., Makela, J.

Number of pages: 8

Pages: 701-708

Publication date: 28 Jun 2018

### Host publication information

Title of host publication: 2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2018

Publisher: IEEE

ISBN (Electronic): 9789532330977

ASJC Scopus subject areas: Electrical and Electronic Engineering, Hardware and Architecture, Signal Processing, Computer Networks and Communications

Keywords: CSS, game programming, HTML5, Internet, IT, JavaScript, SE, university education, working students

DOIs:

10.23919/MIPRO.2018.8400131

Source: Scopus

Source ID: 85050228879

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Full-duplex radio technology for simultaneously detecting and preventing improvised explosive device activation

Originating from civilian/commercial wireless networks, the progressive concept of same frequency simultaneous transmission and reception (SF-STAR), a.k.a. in-band full-duplex operation, has high potential also at the future battlefield. The prospects of a military full-duplex radio (MFDR) are not limited to enhancing the spectral efficiency of tactical communications, which would already be a significant advancement considering the universal congestion of electromagnetic spectrum. Perhaps even more importantly, armed forces could gain a major technical advantage by employing multifunction MFDRs that are capable of jointly conducting signals intelligence, electronic warfare, and tactical communications owing to their SF-STAR capability. This study focuses on one specific promising application, where a radio transceiver performs spectrum monitoring and signal surveillance for potential hostile transmissions when simultaneously performing an electronic attack against opposing forces' receivers at the same frequency band. In particular, we demonstrate by experiments in a laboratory environment that the MFDR technology can be successfully used for detecting an attempt to control remotely an improvised explosive device while also preventing its activation by transmitting a jamming signal.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering

Contributors: Riihonen, T., Korpi, D., Turunen, M., Valkama, M.

Number of pages: 4

Pages: 1-4

Publication date: 27 Jun 2018

### Host publication information

Title of host publication: 2018 International Conference on Military Communications and Information Systems, ICMCIS 2018

Publisher: IEEE

ISBN (Electronic): 9781538645598

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

Electronic versions:

Full-Duplex Radio Technology for Simultaneously Detecting and Preventing Improvised Explosive Device Activation

DOIs:

10.1109/ICMCIS.2018.8398707

URLs:

<http://urn.fi/URN:NBN:fi:tty-201810152396>

### Bibliographical note

INT=elt,"Turunen, Matias"

Source: Scopus

Source ID: 85050255592

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Sample-based regularization for support vector machine classification**

In this paper, we propose a new regularization scheme for the well-known Support Vector Machine (SVM) classifier that operates on the training sample level. The proposed approach is motivated by the fact that Maximum Margin-based classification defines decision functions as a linear combination of the selected training data and, thus, the variations on training sample selection directly affect generalization performance. We show that the exploitation of the proposed regularization scheme is well motivated and intuitive. Experimental results show that the proposed regularization scheme outperforms standard SVM in human action recognition tasks as well as classical recognition problems.

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Signal Processing  
Contributors: Tran, D. T., Waris, M. A., Gabbouj, M., Iosifidis, A.  
Number of pages: 6  
Pages: 1-6  
Publication date: 8 Mar 2018

#### **Host publication information**

Title of host publication: Proceedings of the 7th International Conference on Image Processing Theory, Tools and Applications, IPTA 2017  
Publisher: IEEE  
ISBN (Electronic): 9781538618417  
ASJC Scopus subject areas: Signal Processing, Radiology Nuclear Medicine and imaging  
Keywords: Dropout, kernel methods, Regularization, Support Vector Machine  
DOIs:  
10.1109/IPTA.2017.8310103

#### **Bibliographical note**

INT=sgn,"Tran, Dat Thanh"  
Source: Scopus  
Source ID: 85050655029  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Subaperture image segmentation for lossless compression**

The paper proposes an image segmentation method for lossless compression of plenoptic images. Each light-field image captured by the plenoptic camera is processed to obtain a stack of subaperture images. Each subaperture image is encoded by using a gradient-base detector which classifies the image edges and designs refined contexts for an improved prediction and segmentation. The paper's main contribution is a new segmentation method which generates a preliminary segmentation, either by scaling the intensity differences or by using a quantum cut based algorithm, and merges it with an edge ranking-based segmentation. The results show around 2% improved performance compared to the state-of-the-art for a dataset of 118 plenoptic images.

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Signal Processing, University of Electronic Science and Technology of China  
Contributors: Schioppa, I., Gabbouj, M., Iosifidis, A., Zeng, B., Liu, S.  
Number of pages: 6  
Pages: 1-6  
Publication date: 8 Mar 2018

#### **Host publication information**

Title of host publication: Proceedings of the 7th International Conference on Image Processing Theory, Tools and Applications, IPTA 2017  
Publisher: IEEE  
ISBN (Electronic): 9781538618417  
ASJC Scopus subject areas: Signal Processing, Radiology Nuclear Medicine and imaging  
Keywords: image segmentation, Lossless compression, plenoptic image, quantum cut segmentation  
DOIs:  
10.1109/IPTA.2017.8310083  
Source: Scopus  
Source ID: 85050764396  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review



### **Deep multiresolution color constancy**

In this paper, a computational color constancy method is proposed via estimating the illuminant chromaticity in a scene by pooling from many local estimates. To this end, first, for each image in a dataset, we form an image pyramid consisting of several scales of the original image. Next, local patches of certain size are extracted from each scale in this image pyramid. Then, a convolutional neural network is trained to estimate the illuminant chromaticity per-patch. Finally, two more consecutive trainings are conducted, where the estimation is made per-image via taking the mean (1<sup>st</sup> training) and median (2<sup>nd</sup> training) of local estimates. The proposed method is shown to outperform the state-of-the-art in a widely used color constancy dataset.

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Signal Processing, Intel Finland  
Contributors: Aytekin, C., Nikkanen, J., Gabbouj, M.  
Number of pages: 5  
Pages: 3735-3739  
Publication date: 20 Feb 2018

#### **Host publication information**

Title of host publication: 2017 IEEE International Conference on Image Processing, ICIP 2017 - Proceedings  
Publisher: IEEE COMPUTER SOCIETY PRESS  
ISBN (Electronic): 9781509021758  
ASJC Scopus subject areas: Software, Computer Vision and Pattern Recognition, Signal Processing  
Keywords: Color constancy, Deep learning, Illuminant chromaticity estimation, Local estimation, Multi-resolution  
DOIs:  
10.1109/ICIP.2017.8296980

#### **Bibliographical note**

jufoid=57423  
Source: Scopus  
Source ID: 85045299547  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **360-Degree video streaming and its subjective quality**

Traditional challenges for deploying end-to-end streaming systems are made harder when considering 360-degree media content. One of these challenges relates to the lack of commonly accepted standardized methodologies for subjective 360-degree video quality assessment, especially oriented towards streaming services. The contribution of this paper falls in the area of subjective assessment of 360-degree video. - From traditional standardized test methodologies originally designed for 2D/3D video, we tailored a methodology more oriented towards Virtual Reality (VR) streaming services. The methodology inherits a lot from existing ITU standards for video subjective quality evaluation. The additions incorporate the special properties of 360-video, namely omnidirectionality, as opposed to traditional video. - With this goal in mind, a new metric called Similarity Ring Metric (SRM) is introduced. It measures the degree of similarity in watching patterns of a single subject or between different subjects for several subjective assessment tests. This metric enables an inclusion or rejection criteria for test results in subjective assessment sessions. We also present visual fatigue results related to a subjective quality experiment of 360-degree video.

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Signal Processing, Nokia Technologies  
Contributors: Curcio, I. D., Toukoma, H., Naik, D.  
Number of pages: 23  
Pages: 1-23  
Publication date: 5 Feb 2018

#### **Host publication information**

Title of host publication: SMPTE 2017 Annual Technical Conference and Exhibition, SMPTE 2017  
Publisher: SMPTE  
ISBN (Electronic): 9781614829591  
ASJC Scopus subject areas: Organizational Behavior and Human Resource Management, Computer Networks and Communications, Signal Processing, Information Systems and Management, Media Technology  
Keywords: 360 degrees video, Omnidirectional video, subjective assessment, subjective quality evaluation, test methodology, virtual reality streaming  
DOIs:

10.5594/M001758

#### **Bibliographical note**

EXT="Curcio, Igor D.D."

Source: Scopus

Source ID: 85050404607

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **Model-based dynamic scheduling for multicore implementation of image processing systems**

In this paper, we present a new software tool, called HTGS Model-based Engine (HMBE), for the design and implementation of multicore signal processing applications. HMBE provides complementary capabilities to HTGS (Hybrid Task Graph Scheduler), which is a recently-introduced software tool for implementing scalable workflows for high performance computing applications. HMBE integrates advanced design optimization techniques provided in HTGS with model-based approaches that are founded on dataflow principles. Such integration contributes to (a) making the application of HTGS more systematic and less time consuming, (b) incorporating additional dataflow-based optimization capabilities with HTGS optimizations, and (c) automating significant parts of the HTGS-based design process. In this paper, we present HMBE with an emphasis on novel dynamic scheduling techniques that are developed as part of the tool. We demonstrate the utility of HMBE through a case study involving an image stitching application for large scale microscopy images.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, University of Maryland, National Institute of Standards and Technology

Contributors: Wu, J., Blattner, T., Keyrouz, W., Bhattacharyya, S. S.

Publication date: 14 Nov 2017

#### **Host publication information**

Title of host publication: 2017 IEEE International Workshop on Signal Processing Systems, SiPS 2017

Publisher: IEEE

Article number: 8110003

ISBN (Electronic): 9781538604465

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics, Hardware and Architecture

DOIs:

10.1109/SiPS.2017.8110003

Source: Scopus

Source ID: 85040564128

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **An optimized embedded target detection system using acoustic and seismic sensors**

Detection of targets using low power embedded devices has important applications in border security and surveillance. In this paper, we build on recent algorithmic advances in sensor fusion, and present the design and implementation of a novel, multi-mode embedded signal processing system for detection of people and vehicles using acoustic and seismic sensors. Here, by "multi-mode", we mean that the system has available a complementary set of configurations that are optimized for different trade-offs. The multimode capability delivered by the proposed system is useful to supporting long lifetime (long term, energy-efficient "standby" operation), while also supporting optimized accuracy during critical time periods (e.g., when a potential threat is detected). In our target detection system, we apply a strategically-configured suite of single-and dual-modality signal processing techniques together with dataflow-based design optimization for energyefficient, real-time implementation. Through experiments using a Raspberry Pi platform, we demonstrate the capability of our target detection system to provide efficient operational tradeoffs among detection accuracy, energy efficiency, and processing speed.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, Research area: Computer engineering, University of Maryland, U.S. Army Research Laboratory, Department of Electrical and Computer Engineering

Contributors: Lee, K., Riggan, B. S., Bhattacharyya, S. S.

Number of pages: 5

Pages: 986-990

Publication date: 23 Oct 2017

#### **Host publication information**

Title of host publication: 25th European Signal Processing Conference, EUSIPCO 2017

Publisher: IEEE  
ISBN (Electronic): 9780992862671  
ASJC Scopus subject areas: Signal Processing  
DOIs:  
10.23919/EUSIPCO.2017.8081355  
URLs:  
<http://www.eurasip.org/Proceedings/Eusipco/Eusipco2017/papers/1570347422.pdf>

#### **Bibliographical note**

jufoid=55867  
Source: Scopus  
Source ID: 85041468751  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **Full search equivalent fast block matching using orthonormal tree-structured haar transform**

The goal of block matching is to find small parts (blocks) of an image that are similar to a given pattern (template). A lot of full search (FS) equivalent algorithms are based on transforms. However, the template size is limited to be a power-of-two. In this paper, we consider a fast block matching algorithm based on orthonormal tree-structured Haar transform (OTSHT) which makes it possible to use a template with arbitrary size. We evaluated the pruning performance, computational complexity, and design of tree. The pruning performance is compared to the algorithm based on orthonormal Haar transform (OHT).

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Signal Processing, Tokyo Institute of Technology  
Contributors: Ito, I., Egiazarian, K.  
Number of pages: 6  
Pages: 177-182  
Publication date: 18 Oct 2017

#### **Host publication information**

Title of host publication: ISPA 2017 - 10th International Symposium on Image and Signal Processing and Analysis  
Publisher: IEEE COMPUTER SOCIETY PRESS  
ISBN (Electronic): 9781509040117  
ASJC Scopus subject areas: Computational Theory and Mathematics, Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Signal Processing  
DOIs:  
10.1109/ISPA.2017.8073591

#### **Bibliographical note**

jufoid=57665  
Source: Scopus  
Source ID: 85037808698  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **Lossless compression of high resolution disparity map images**

High resolution disparity images are stored in floating point raw files, where the number of bits per pixel is typically 32, although the number of used bits when converted to a fixed point representation is lower, e.g., between 24 and 26 in the dataset used in our experiments. In order to compress images with such high dynamic range, the bitplanes of the original image are combined into integer images with at most 16 bits, for which readily existing compressors are available. We introduce first a context predictive compressor (CPC) which can operate on integer images having more than 16 bits. The proposed overall compression scheme uses a first reversible linear transformation of the image as a first decorrelation process, and then splits the transformed image into integer images with smaller dynamic range, which are finally encoded. We experiment with schemes of split-into-2 and split-into-3, with combinations of several existing compressors for the integer image components and show that the newly introduced CPC operating over the least significant bitplanes combined with CERV operating over the most significant bitplanes achieves always the best compression, with final lossless compressed results of between 8 and 12 bits per pixel.

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Signal Processing, Research group: Signal Interpretation and Compression-SIC  
Contributors: Astola, P., Tabus, I.

Publication date: 12 Sep 2017

#### Host publication information

Title of host publication: ISSCS 2017 - International Symposium on Signals, Circuits and Systems

Publisher: IEEE

ISBN (Electronic): 9781538606742

ASJC Scopus subject areas: Computer Networks and Communications, Electrical and Electronic Engineering, Signal Processing

DOIs:

10.1109/ISSCS.2017.8034934

Source: Scopus

Source ID: 85032263668

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Convergence analysis of error-reduction algorithm for solving of the extended one-dimensional discrete phase retrieval problem

The iterative methods are well-known approaches to solve the one-dimensional phase retrieval problem. Amongst them, the error-reduction algorithm is often used since it can easily implement support constraints. Unfortunately this method often stagnates. Recently we have formulated the extended form of the one-dimensional discrete phase retrieval problem and we have assumed that the stagnation can be avoided by oversampling. Simulations have indicated that the conjecture is true. In this work we prove the convergence of the error-reduction algorithm in the proposed extended one-dimensional discrete phase retrieval framework.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Technical University of Cluj-Napoca Universitatea Tehnica din Cluj-Napoca

Contributors: Rusu, C., Astola, J.

Publication date: 12 Sep 2017

#### Host publication information

Title of host publication: ISSCS 2017 - International Symposium on Signals, Circuits and Systems

Publisher: IEEE

ISBN (Electronic): 9781538606742

ASJC Scopus subject areas: Computer Networks and Communications, Electrical and Electronic Engineering, Signal Processing

DOIs:

10.1109/ISSCS.2017.8034945

#### Bibliographical note

EXT="Rusu, Corneliu"

Source: Scopus

Source ID: 85032302395

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Angular wall loss model and Extended Building Penetration model for outdoor to indoor propagation

The main target of this research work is to study the provision of indoor service (coverage) using outdoor base stations at higher frequencies i.e. 10 GHz in the context of a single building scenario. In an outdoor to indoor propagation, an angular wall loss model is used in the General Building Penetration (GBP) model for estimating the additional loss at the intercept point of the building exterior wall. A novel angular wall loss model based on a separate incidence angle in azimuth and elevation plane is proposed in this paper. In the second part of this study, an Extended Building Penetration (EBP) model is proposed, and the performance of EBP model is compared with the GBP model. In EBP model, the additional fifth path known as the 'Direct path' is proposed to be included in the GBP model. Based on the evaluation results, the impact of the direct path is found significant for the indoor users having the same or closed by height as that of the height of the transmitter.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering, Research group: Laboratory of Radio Network Planning, Research group: Wireless Communications and Positioning, Ericsson Research

Contributors: Sheikh, M. U., Hiltunen, K., Lempäinen, J.

Number of pages: 6

Pages: 1291-1296

Publication date: 19 Jul 2017

### Host publication information

Title of host publication: 2017 13th International Wireless Communications and Mobile Computing Conference, IWCMC 2017

Publisher: IEEE

ISBN (Electronic): 9781509043729

ASJC Scopus subject areas: Computer Networks and Communications, Hardware and Architecture, Signal Processing

Keywords: Angular loss, Building penetration loss, Outdoor to Indoor, Propagation, Wall loss model

DOIs:

10.1109/IWCMC.2017.7986471

Source: Scopus

Source ID: 85027886696

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Analysis of multipath propagation for 5G system at higher frequencies in microcellular environment

The main target of this paper is to perform the multidimensional analysis of multipath propagation at higher frequencies i.e. 15 GHz and 28 GHz, using 'sAGA' a 3D ray tracing tool. A real world outdoor Line of Sight (LOS) microcellular environment from the Yokusuka city of Japan is considered for the analysis. The simulation data acquired from the 3D ray tracing tool includes the received signal strength, power angular spectrum and the power delay profile. The different propagation mechanisms were closely analyzed. The simulation results show the difference of propagation at two frequencies i.e. 15 GHz and 28 GHz and draw a special attention on the impact of diffuse scattering at 28 GHz. In a simple outdoor microcellular environment with a valid LOS link between the transmitter and a receiver, a path loss difference of around 5.7 dB was found between 15 GHz and 28 GHz frequency of operation. However, the propagation loss at higher frequency can be compensated by using the antenna with narrow beamwidth and larger gain.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering, Research group: Laboratory of Radio Network Planning,

Research group: Wireless Communications and Positioning

Contributors: Sheikh, M. U., Lempiäinen, J.

Number of pages: 5

Pages: 1660-1664

Publication date: 19 Jul 2017

### Host publication information

Title of host publication: 2017 13th International Wireless Communications and Mobile Computing Conference, IWCMC 2017

Publisher: IEEE

ISBN (Electronic): 9781509043729

ASJC Scopus subject areas: Computer Networks and Communications, Hardware and Architecture, Signal Processing

Keywords: 3D ray tracing, 5G, Microcellular, Multipath propagation, System performance

DOIs:

10.1109/IWCMC.2017.7986533

Source: Scopus

Source ID: 85027853365

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Reduced-complexity digital predistortion for massive MIMO

A novel reduced-complexity digital predistortion (DPD) solution is presented in this paper. The proposed DPD can suppress the unwanted distortions due to power amplifier (PA) nonlinearity and I/Q modulator impairments in direct conversion transmitters using reduced-bandwidth filtered basis functions. Moreover, the DPD parameter estimation is based on very simple decorrelation based closed-loop processing and reduced-bandwidth observation, thus further reducing the overall complexity. The proposed DPD can be used in large array or massive MIMO systems with large number of radio transceivers and PAs, where reducing the complexity of the DPD processing is very critical.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering, Research group: Wireless Communications and Positioning

Contributors: Abdelaziz, M., Anttila, L., Valkama, M.

Number of pages: 5

Pages: 6478-6482

Publication date: 16 Jun 2017

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Publisher: IEEE

ISBN (Electronic): 9781509041176

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: 5G, Digital Predistortion, Direct Conversion Transmitters, I/Q imbalance, Massive MIMO, Power Amplifiers

Electronic versions:

Reduced-complexity digital predistortion 2017

DOIs:

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URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002132040>

Source: Scopus

Source ID: 85023738523

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### A k-nearest neighbor multilabel ranking algorithm with application to content-based image retrieval

Multilabel ranking is an important machine learning task with many applications, such as content-based image retrieval (CBIR). However, when the number of labels is large, traditional algorithms are either infeasible or show poor performance. In this paper, we propose a simple yet effective multilabel ranking algorithm that is based on k-nearest neighbor paradigm. The proposed algorithm ranks labels according to the probabilities of the label association using the neighboring samples around a query sample. Different from traditional approaches, we take only positive samples into consideration and determine the model parameters by directly optimizing ranking loss measures. We evaluated the proposed algorithm using four popular multilabel datasets. The proposed algorithm achieves equivalent or better performance than other instance-based learning algorithms. When applied to a CBIR system with a dataset of 1 million samples and over 190 thousand labels, which is much larger than any other multilabel datasets used earlier, the proposed algorithm clearly outperforms the competing algorithms.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Multimedia Research Group - MRG, Qatar University

Contributors: Zhang, H., Kiranyaz, S., Gabbouj, M.

Number of pages: 5

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Publication date: 16 Jun 2017

### Host publication information

Title of host publication: 2017 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2017 - Proceedings

Publisher: IEEE

ISBN (Electronic): 9781509041176

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Content-Based Image Retrieval, k-Nearest Neighbor, Multilabel Learning

DOIs:

10.1109/ICASSP.2017.7952624

Source: Scopus

Source ID: 85023746875

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Inband full-duplex radio access system with self-backhauling: Transmit power minimization under QoS requirements

In this paper, a self-backhauling radio access system is studied and analyzed. In particular, we consider a scenario where a full-duplex access node is serving mobile users simultaneously in uplink and downlink, while also maintaining a wireless backhaul connection. The full-duplex capability of the access node, together with large antenna arrays, allows it to do all of this using the same center frequency. The minimum transmit powers for such a system are solved in a closed form under the condition that certain Quality of Service (QoS) requirements, defined in terms of minimum uplink and downlink data rates, are fulfilled. It is demonstrated with numerical results that, by using the derived expressions for the optimal transmit powers, the probability of fulfilling the QoS requirements is greatly increased, while simultaneously the overall transmit power usage of the system is significantly reduced when compared to a benchmark scheme.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Aalto University  
Contributors: Korpi, D., Riihonen, T., Valkama, M.  
Number of pages: 5  
Pages: 6558-6562  
Publication date: 16 Jun 2017

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Title of host publication: 2017 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2017 - Proceedings  
Publisher: IEEE  
ISBN (Electronic): 9781509041176  
ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering  
Keywords: Full-duplex, massive MIMO, self-backhauling  
Electronic versions:  
Inband full-duplex radio access system 2017  
DOIs:  
10.1109/ICASSP.2017.7953420  
URLs:  
<http://urn.fi/URN:NBN:fi:tuni-202002061908>  
Source: Scopus  
Source ID: 85023776611  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### An accumulative fusion architecture for discriminating people and vehicles using acoustic and seismic signals

In this paper, we develop new multiclass classification algorithms for detecting people and vehicles by fusing data from a multimodal, unattended ground sensor node. The specific types of sensors that we apply in this work are acoustic and seismic sensors. We investigate two alternative approaches to multiclass classification in this context - the first is based on applying Dempster-Shafer Theory to perform score-level fusion, and the second involves the accumulation of local similarity evidences derived from a feature-level fusion model that combines both modalities. We experiment with the proposed algorithms using different datasets obtained from acoustic and seismic sensors in various outdoor environments, and evaluate the performance of the two algorithms in terms of receiver operating characteristic and classification accuracy. Our results demonstrate overall superiority of the proposed new feature-level fusion approach for multiclass discrimination among people, vehicles and noise.

#### General information

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Pervasive Computing, U.S. Army Research Laboratory, Department of Electrical and Computer Engineering, University of Maryland  
Contributors: Lee, K., Riggan, B. S., Bhattacharyya, S. S.  
Number of pages: 5  
Pages: 2976-2980  
Publication date: 16 Jun 2017

#### Host publication information

Title of host publication: 2017 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2017 - Proceedings  
Publisher: IEEE  
ISBN (Electronic): 9781509041176  
ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering  
Keywords: multiclass classification, Sensor fusion, target detection, tracking  
DOIs:  
10.1109/ICASSP.2017.7952702  
Source: Scopus  
Source ID: 85023750747  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### The variation of air and surface temperatures in London within a 1km grid using vehicle-transect and ASTER data

Urbanisation can modify the local climate, increasing the temperature of cities compared to rural areas. This phenomenon is known as the Urban Heat Island (UHI), and this paper introduces a methodology to investigate the spatial variability of air and surface temperatures across London. In particular, this study aims to investigate if a widely used spatial resolution (1 km) is appropriate for heat-related health risk studies. Data from vehicle-transect and ASTER thermal images were overlaid on a reference grid of 1 km, used by UHI simulation models. The results showed higher variability of air temperature within some specific modelled grid cells in the city centre, while surface temperatures presented higher

variability in the London borders. This investigation suggests that LST has larger variation levels and more grid cells with sub-grid variation above 1°C compared to air temperature measurements.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: University College London, London School of Hygiene and Tropical Medicine

Contributors: Dos Santos, R. S., Taylor, J., Davies, M., Mavrogianni, A., Milner, J.

Publication date: 10 May 2017

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Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 7924613

ISBN (Electronic): 9781509058082

#### Publication series

Name: 2017 Joint Urban Remote Sensing Event, JURSE 2017

ASJC Scopus subject areas: Signal Processing, Urban Studies, Management, Monitoring, Policy and Law, Instrumentation

DOIs:

10.1109/JURSE.2017.7924613

URLs:

<http://www.scopus.com/inward/record.url?scp=85020236643&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 85020236643

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### The Effect of Light Field Reconstruction and Angular Resolution Reduction on the Quality of Experience

The quality of visual contents displayed on 3D autostereoscopic displays—such as light field displays—essentially depend on factors that are not present in case of 3D stereoscopic or 2D ones, like angular resolution. A higher number of views in a given field of view enables a smoother, continuous motion parallax, but evidently requires more resources to transmit and display. However, in several cases a sufficiently high number of views might not even be available, thus light field reconstruction is required to increase the density of intermediate views. In this paper we introduce the results of a research aiming to measure the perceptual difference between light field reconstruction and different angular resolutions via a series of subjective image quality assessments. The analysis also calls attention to transmission requirements of content for light field displays.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: 3D MEDIA, Robotic Vision Team, Kingston University, Holografika

Contributors: Kara, P. A., Kovacs, P. T., Vagharshakyan, S., Martini, M. G., Barsi, A., Balogh, T., Chuchvara, A., Chehaibi, A.

Number of pages: 6

Pages: 781-786

Publication date: 21 Apr 2017

#### Host publication information

Title of host publication: 2016 12th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)

Publisher: IEEE

ISBN (Electronic): 9781509056989

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Radiology Nuclear Medicine and imaging, Computer Networks and Communications, Signal Processing

Keywords: Angular Resolution, Image Quality, Light Field Display, Light Field Reconstruction, Perceived Quality, Quality of Experience, View Synthesis

DOIs:

10.1109/SITIS.2016.128

Source: Scopus

Source ID: 85019236013

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review



### **HEVC-compliant viewport-adaptive streaming of stereoscopic panoramic video**

Virtual reality (VR) provides unprecedented immersive experience using high-resolution spherical stereoscopic panoramic video. Such an experience is achieved by using head-mounted display (HMD) which has very strict latency bounds in order to respond promptly to user movements. Conventional streaming of VR video requires large bandwidth because the entire captured panorama is transmitted. However, only a limited field-of-view (FOV) is displayed by an HMD, resulting in wastage of bandwidth. To alleviate the problem, this paper proposes a High Efficiency Video Coding (HEVC) compliant approach for efficient coding and streaming of stereoscopic VR content. The proposed method is based on partitioning video pictures into tiles, where only the required tiles corresponding to the primary viewport are transmitted in high resolution, while the remaining parts are transmitted in low resolution. Furthermore, this method enables coding stereoscopic video contents using a conventional HEVC codec, while still achieving significant compression gain by means of adopting inter-view prediction only in intra random access point (IRAP) pictures. Using this method, the predicted view can be decoded independently of the main view, hence allowing simultaneous decoding instances. Experimental results demonstrate that the proposed approach is able to substantially improve compression efficiency and streaming bitrate performance.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Multimedia Research Group - MRG, Nokia

Contributors: Zare, A., Sreedhar, K. K., Vadakital, V. K. M., Aminlou, A., Hannuksela, M. M., Gabbouj, M.

Publication date: 19 Apr 2017

#### **Host publication information**

Title of host publication: 2016 Picture Coding Symposium, PCS 2016

Publisher: IEEE

ISBN (Electronic): 9781509059669

ASJC Scopus subject areas: Media Technology, Signal Processing

DOIs:

10.1109/PCS.2016.7906401

#### **Bibliographical note**

EXT="Vadakital, Vinod Kumar Malamal"

Source: Scopus

Source ID: 85019449939

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Compact modeling and management of reconfiguration in digital channelizer implementation**

In this work, a novel digital channelizer design is developed through the use of a compact, system-level modeling approach. The model efficiently captures key properties of a digital channelizer system and its time-varying operation. The model applies powerful Markov Decision Process (MDP) techniques in new ways for design optimization of reconfigurable channelization processing. The result is a promising methodology for design and implementation of digital channelizers that adapt dynamically to changing use cases and stochastic environments while optimizing simultaneously for multiple conflicting performance goals. The method is used to employ an MDP to generate a runtime reconfiguration policy for a time-varying environment. Through extensive simulations, the robustness of the adaptation is demonstrated in comparison with the prior state of the art.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, University of Maryland, Georgia Institute of Technology

Contributors: Sapio, A. E., Wolf, M., Bhattacharyya, S. S.

Number of pages: 5

Pages: 595-599

Publication date: 19 Apr 2017

#### **Host publication information**

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Publisher: IEEE

ISBN (Electronic): 9781509045457

ASJC Scopus subject areas: Signal Processing, Computer Networks and Communications

Keywords: Channelizer, Markov decision processes, Reconfigurable architectures, Software defined radio

DOIs:

10.1109/GlobalSIP.2016.7905911

Source: Scopus

Source ID: 85019194314

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Advanced architectures for self-interference cancellation in full-duplex radios: Algorithms and measurements**

In this paper, we describe an advanced real-time cancellation architecture for efficient digital-domain suppression of self-interference in inband full-duplex devices. The digital canceller takes into account the nonlinear distortion produced by the transmitter power amplifier, and is thereby a robust solution for low-cost implementations. The developed real-time digital canceller implementation is then evaluated with actual RF measurements, where it is complemented with a real-time adaptive RF canceller. The obtained results show that the RF canceller and the developed digital canceller implementation can together cancel the residual self-interference below the receiver noise floor in real-time for a 20 MHz cancellation bandwidth.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Electronics and Communications Engineering, Research group: Wireless Communications and Positioning

Contributors: Korpi, D., Aghababaeetafreshi, M., Piilila, M., Anttila, L., Valkama, M.

Number of pages: 5

Pages: 1553-1557

Publication date: 1 Mar 2017

#### **Host publication information**

Title of host publication: 2016 50th Asilomar Conference on Signals, Systems and Computers

Publisher: IEEE

ISBN (Electronic): 9781538639542

ASJC Scopus subject areas: Signal Processing, Computer Networks and Communications

Electronic versions:

Advanced Architectures for Self-interference Cancellation 2017

DOIs:

10.1109/ACSSC.2016.7869639

URLs:

<http://urn.fi/URN:NBN:fi:tuni-202002071927>

#### **Bibliographical note**

INT=elt,"Piilila, Mauno"

Source: Scopus

Source ID: 85016330499

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Low power design methodology for signal processing systems using lightweight dataflow techniques**

Dataflow modeling techniques facilitate many aspects of design exploration and optimization for signal processing systems, such as efficient scheduling, memory management, and task synchronization. The lightweight dataflow (LWDF) programming methodology provides an abstract programming model that supports dataflow-based design and implementation of signal processing hardware and software components and systems. Previous work on LWDF techniques has emphasized their application to DSP software implementation. In this paper, we present new extensions of the LWDF methodology for effective integration with hardware description languages (HDLs), and we apply these extensions to develop efficient methods for low power DSP hardware implementation. Through a case study of a deep neural network application for vehicle classification, we demonstrate our proposed LWDF-based hardware design methodology, and its effectiveness in low power implementation of complex signal processing systems.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, Signal Processing, Research group: Vision, Research area: Computer engineering, University of Maryland, Dept. of Electrical and Electronic Engineering, PolComIng - Information Engineering Unit, Department of Electrical and Computer Engineering

Contributors: Li, L., Fanni, T., Viitanen, T., Xie, R., Palumbo, F., Raffo, L., Huttunen, H., Takala, J., Bhattacharyya, S. S.

Number of pages: 8

Pages: 82-89

Publication date: 13 Feb 2017

#### **Host publication information**

Title of host publication: DASIP 2016 - Proceedings of the 2016 Conference on Design and Architectures for Signal and Image Processing

Publisher: IEEE COMPUTER SOCIETY PRESS

ISBN (Electronic): 9791092279153

ASJC Scopus subject areas: Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

DOIs:

10.1109/DASIP.2016.7853801

#### **Bibliographical note**

INT=tie,"Xie, Renjie"

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **Color-distribution similarity by information theoretic divergence for color images**

The divergence similarity between two color images is presented based on the Jensen-Shannon divergence to measure the color-distribution similarity. Subjective assessment experiments were developed to obtain mean opinion scores (MOS) of test images. It was found that the divergence similarity and MOS values showed statistically significant correlations.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing, Research group: Vision, University of Niigata, KLab, Japan, K-JIST, Dongguk University, Seoul

Contributors: Murayama, M., Oguro, D., Kikuchi, H., Huttunen, H., Ho, Y. S., Shin, J.

Publication date: 17 Jan 2017

#### **Host publication information**

Title of host publication: 2016 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference, APSIPA 2016

Publisher: IEEE

ISBN (Electronic): 9789881476821

ASJC Scopus subject areas: Artificial Intelligence, Computer Science Applications, Information Systems, Signal Processing

DOIs:

10.1109/APSIPA.2016.7820681

#### **Bibliographical note**

JUFOID=72850

Source: Scopus

Source ID: 85013813769

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **Models of architecture: Reproducible efficiency evaluation for signal processing systems**

The current trend in high performance and embedded signal processing consists of designing increasingly complex heterogeneous hardware architectures with non-uniform communication resources. In order to take hardware and software design decisions, early evaluations of the system non-functional properties are needed. These evaluations of system efficiency require high-level information on both the algorithms and the architecture. In this paper, we define the notion of Model of Architecture (MoA) and study the combination of a Model of Computation (MoC) and an MoA to provide a design space exploration environment for the study of the algorithmic and architectural choices. A cost is computed from the mapping of an application, represented by a model conforming a MoC onto an architecture represented by a model conforming an MoA. The cost is composed of a processing-related part and a communication-related part. It is an abstract scalar value to be minimized and can represent any non-functional requirement of a system such as memory, energy, throughput or latency.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Pervasive Computing, Research area: Computer engineering, Institut Pascal, UBL, Scuola Superiore sant'Anna, Salzburg University of Applied Sciences, University of Maryland

Contributors: Pelcat, M., Desnos, K., Maggiani, L., Liu, Y., Heulot, J., Nezan, J. F., Bhattacharyya, S. S.

Number of pages: 6

Pages: 121-126

Publication date: 9 Dec 2016

#### **Host publication information**

Title of host publication: IEEE International Workshop on Signal Processing Systems, SiPS 2016

Publisher: IEEE

Article number: 7780083  
ISBN (Electronic): 9781509033614

### Publication series

Name: IEEE International Workshop on Signal Processing Systems

ISSN (Electronic): 2374-7390

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics, Hardware and Architecture

DOIs:

10.1109/SiPS.2016.29

Source: Scopus

Source ID: 85013141986

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Improved image quality in fast inpainting with omnidirectional filling

Image inpainting is an active research field of image processing. Previous inpainting methods often require a long computational time to give sufficient results, especially due to the extensive search process of exemplar-based methods. This work improves a previous fast inpainting method based on local similarity, which achieves runtimes measured in tens of milliseconds per image, but often results in unacceptable artifacts. We improve the resulting image quality by allowing pixels to be filled at any angle, determining the angle based only on the vicinity of the target region, and cross-fading between source pixels from opposite sides of the target region. The proposed method is shown to eliminate the two drawbacks, while retaining a fast runtime.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Pervasive Computing, Research area: Computer engineering, School of Science, Tohoku University

Contributors: Hirvola, O., Viitanen, T., Sintunata, V., Aoki, T.

Number of pages: 5

Pages: 31-35

Publication date: 22 Sep 2016

### Host publication information

Title of host publication: International Conference on Image, Vision and Computing (ICIVC)

Publisher: IEEE

ISBN (Print): 978-1-5090-3756-8

ISBN (Electronic): 978-1-5090-3755-1

ASJC Scopus subject areas: Signal Processing

DOIs:

10.1109/ICIVC.2016.7571269

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Automatic objective thresholding to detect neuronal action potentials

In this paper, we introduce a fully objective method to set thresholds (THs) for neuronal action potential spike detection from extracellular field potential signals. Although several more sophisticated methods exist, thresholding is still the most used spike detection method. In general, it is employed by setting a TH as per convention or operator decision, and without considering either the undetected or spurious spikes. Here, we demonstrate with both simulations and real microelectrode measurement data that our method can fully automatically and objectively yield THs comparable to those set by an expert operator. A Matlab function implementation of the method is described, and provided freely in Matlab Central File Exchange.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, Research group: Computational Biophysics and Imaging Group, Department of Pervasive Computing, BioMediTech

Contributors: Tanskanen, J. M., Kapucu, F. E., Välikki, I., Hyttinen, J. A.

Number of pages: 5

Pages: 662-666

Publication date: 29 Aug 2016

### Host publication information

Title of host publication: Proceedings of 2016 24th European Signal Processing Conference (EUSIPCO)

ISBN (Print): 978-1-5090-1891-8

ISBN (Electronic): 978-0-9928-6265-7

ASJC Scopus subject areas: Signal Processing, Neuroscience(all)

Keywords: Neuronal action potential, Thresholding, Spike detection, Microelectrode array, Electric field potential

Electronic versions:

EUSIPCO2016\_Tanskanen

DOIs:

10.1109/EUSIPCO.2016.7760331

URLs:

<http://urn.fi/URN:NBN:fi:tty-201612124857>

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Supervised subspace learning based on deep randomized networks**

In this paper, we propose a supervised subspace learning method that exploits the rich representation power of deep feedforward networks. In order to derive a fast, yet efficient, learning scheme we employ deep randomized neural networks that have been recently shown to provide good compromise between training speed and performance. For optimally determining the learnt subspace, we formulate a regression problem where we employ target vectors designed to encode both the labeling information available for the training data and geometric properties of the training data, when represented in the feature space determined by the network's last hidden layer outputs. We experimentally show that the proposed approach is able to outperform deep randomized neural networks trained by using the standard network target vectors.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Video

Contributors: Iosifidis, A., Gabbouj, M.

Number of pages: 5

Pages: 2584-2588

Publication date: 18 May 2016

#### **Host publication information**

Title of host publication: 2016 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)

Publisher: The Institute of Electrical and Electronics Engineers, Inc.

ISBN (Print): 9781479999880

ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: Deep Neural Networks, Network targets calculation, Supervised Subspace Learning

DOIs:

10.1109/ICASSP.2016.7472144

Source: Scopus

Source ID: 84973351642

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **On Rényi's entropy estimation with one-dimensional Gaussian kernels**

Rényi's entropies play a significant role in many signal processing applications. Plug-in kernel density estimation methods have been employed to estimate such entropies with good results. However, they become computationally intractable in higher dimensions, because of the requirement to store intermediate probability density values for a large number of data points. We propose a method to reduce the number of the samples in a plug-in kernel density estimation method for Rényi's entropies of real exponents and to improve the result of the standard plug-in kernel density method. To this end, we derive a univariate estimator, using an Hermite expansion of sums of Gaussian kernels and a hierarchical clustering of the samples. On simulated data from a univariate Gaussian distribution, our method performs better than a k-nearest neighbour algorithm and other kernel density estimation methods.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing

Contributors: Sarbu, S.

Number of pages: 5

Pages: 4408-4412

Publication date: 18 May 2016

#### **Host publication information**

Title of host publication: 2016 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)

Publisher: IEEE

ISBN (Print): 9781479999880

ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: Gaussian kernels, Hermite expansion, hierarchical clustering, Rényi's entropy estimation

DOIs:

10.1109/ICASSP.2016.7472510

Source: Scopus

Source ID: 84973308366

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Blind sub-Nyquist GNSS signal detection**

A satellite navigation receiver traditionally searches for positioning signals using an acquisition procedure. In situations, in which the required information is only a binary decision whether at least one positioning signal is present or absent, the procedure represents an unnecessarily complex solution. This paper presents a different approach for the binary detection problem with significantly reduced computational complexity. The approach is based on a novel decision metric which is utilized to design two binary detectors. The first detector operates under the theoretical assumption of additive white Gaussian noise and is evaluated by means of Receiver Operating Characteristics. The second one considers also additional interferences and is suitable to operate in a real environment. Its performance is verified using a signal captured by a receiver front-end.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, Department of Mathematics, Research group: MAT Intelligent Information Systems Laboratory, Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing, Advanced Technology Europe, Nottingham Geospatial Institute, University of Nottingham, Chalmers University of Technology

Contributors: Daniel, O., Raasakka, J., Peltola, P., Fröhle, M., Rivero-Rodriguez, A., Wymeersch, H., Nurmi, J.

Number of pages: 5

Pages: 6575-6579

Publication date: 18 May 2016

### **Host publication information**

Title of host publication: 2016 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)

Publisher: IEEE

ISBN (Print): 9781479999880

ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: Global Navigation Satellite Systems, indoor/outdoor detection, signal detection

DOIs:

10.1109/ICASSP.2016.7472944

### **Bibliographical note**

EXT="Raasakka, Jussi"

EXT="Peltola, Pekka"

Source: Scopus

Source ID: 84973379949

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Coordinating proactive social devices in a mobile cloud: Lessons learned and a way forward**

Recent device shipment trends strongly indicate that the number of Web-enabled devices other than PCs and smart phones are growing rapidly. Marking the end of the dominant era of these two traditional device categories, people will soon commonly use various types of Internet-connected devices in their daily lives, where no single device will dominate. Since today's devices are mostly standalone and only stay in sync in limited ways, new approaches are needed for mastering the complexity arising from the world of many types of devices, created by different manufacturers and implementing competing standards. Today, the most common denominator for dealing with the differences is using clouds. Unfortunately, however, while the cloud is well suited for numerous activities, there are also serious limitations, especially when considering systems that consist of numerous, battery-powered computing devices that have limited connectivity. In this paper, we provide an insight to our research where totally cloud-based orchestration of cooperating devices is partitioned into more local actions, where constant communication with the cloud backend can be at least partially omitted.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Pervasive Computing, Research area: Software engineering

Contributors: Mäkitalo, N., Aaltonen, T., Mikkonen, T.

Number of pages: 10  
Pages: 179-188  
Publication date: 14 May 2016

#### Host publication information

Title of host publication: MOBILESoft '16 Proceedings of the International Conference on Mobile Software Engineering and Systems

Publisher: ACM

ISBN (Electronic): 9781450341783

ASJC Scopus subject areas: Control and Systems Engineering, Software, Computer Science Applications, Signal Processing

Keywords: Cloud computing, Cyber-physical systems, Internet of things, Mobile cloud, Multi-device ownership, Multi-device programming

DOIs:

10.1145/2897073.2897079

Source: Scopus

Source ID: 84983554842

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### On prediction of DCT-based denoising efficiency under spatially correlated noise conditions

In this paper, results of image denoising efficiency prediction for filter based on discrete cosine transform (DCT) for the case of spatially correlated additive Gaussian Noise (SCGN) are given. The considered noise model is analyzed for different degrees of spatial correlation that produce varying non-homogeneous spectrum of the noise. PSNR metric is exploited to assess denoising efficiency. It is shown in this paper, that a prediction of denoising efficiency has high accuracy for data distorted by noise with different degrees of spatial correlation, and require low computational resources.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Computational Imaging-CI, Kharkiv National Aerospace University

Contributors: Rubel, O., Lukin, V., Egiazarian, K.

Number of pages: 5

Pages: 750-754

Publication date: 12 Apr 2016

#### Host publication information

Title of host publication: 2016 13th International Conference on Modern Problems of Radio Engineering, Telecommunications and Computer Science (TCSET)

Publisher: IEEE

ISBN (Print): 9786176078067

ASJC Scopus subject areas: Computer Networks and Communications, Electrical and Electronic Engineering, Instrumentation, Radiation, Computer Science (miscellaneous), Signal Processing, Modelling and Simulation

Keywords: Denoising, Efficiency Prediction, Fitting, Spatially Correlated Noise

DOIs:

10.1109/TCSET.2016.7452171

Source: Scopus

Source ID: 84969277857

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### BL-LDA: Bringing bigram to supervised topic model

With the increasing amount of data being published on the Web, it is difficult to analyze their content within a short time. Topic modeling techniques can summarize textual data that contains several topics. Both the label (such as category or tag) and word co-occurrence play a significant role in understanding textual data. However, many conventional topic modeling techniques are limited to the bag-of-words assumption. In this paper, we develop a probabilistic model called Bigram Labeled Latent Dirichlet Allocation (BL-LDA), to address the limitation of the bag-of-words assumption. The proposed BL-LDA incorporates the bigram into the Labeled LDA (L-LDA) technique. Extensive experiments on Yelp data show that the proposed scheme is better than the L-LDA in terms of accuracy.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Research Community on Data-to-Decision (D2D), Korea University

Contributors: Park, Y., Alam, M. H., Ryu, W. J., Lee, S.

Number of pages: 6  
Pages: 83-88  
Publication date: 2 Mar 2016

#### Host publication information

Title of host publication: Proceedings - 2015 International Conference on Computational Science and Computational Intelligence, CSCI 2015

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 7424068

ISBN (Electronic): 9781467397957

ASJC Scopus subject areas: Computational Theory and Mathematics, Artificial Intelligence, Computer Networks and Communications, Hardware and Architecture, Signal Processing

Keywords: Data Analysis, Data Mining, Text Classification, Topic Modeling

DOIs:

10.1109/CSCI.2015.146

URLs:

<http://www.scopus.com/inward/record.url?scp=84964476038&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84964476038

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Random Value Impulse Noise Removal Based on Most Similar Neighbors

A novel filter based on four most similar neighbors (MSN) is proposed in this paper which considers all the pixels of the sliding window except the central pixel after taking the first order absolute differences from the central pixel. The proposed filter is composed of two steps: noise detection followed by filtering. In noise detection, first order absolute differences are calculated and sorted in ascending order. Clusters of equal sizes are formed based on most similar pixels and then fuzzy rules are applied to detect the noise present in the current pixel. Threshold parameters are set adaptively. In filtering phase, median based fuzzy filter is used to restore the corrupted pixels. Experimental results show that the proposed filter outperforms several state-of-the-art filters for random value impulse noise removal in an image.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, International Islamic University Islamabad

Contributors: Habib, M., Rasheed, S., Hussain, A., Ali, M.

Number of pages: 5

Pages: 329-333

Publication date: 26 Feb 2016

#### Host publication information

Title of host publication: 2015 13th International Conference on Frontiers of Information Technology (FIT)

Publisher: IEEE

ISBN (Print): 9781467396660

ASJC Scopus subject areas: Health Informatics, Computer Science Applications, Signal Processing

Keywords: fuzzy logic, Image processing, impulse noise, noise removal

DOIs:

10.1109/FIT.2015.64

#### Bibliographical note

INT=elt,"Ali, Mubashir"

Source: Scopus

Source ID: 84964689604

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Digital full-band linearization of wideband direct-conversion receiver for radar and communications applications

This paper proposes a fully digital post-processing solution for cancelling nonlinear distortion and mirror-frequency interference in wideband direct-conversion receivers (DCRs). Favorable cost, integrability, and power efficiency have made DCRs a popular choice in communication systems. It is also an emerging trend in radar systems since digital post-processing enables sufficient performance. The proposed method cancels the most essential distortion adaptively during normal receiver operation without any prior information. Improved cancellation performance compared to the state-of-the-art is achieved considering inband and neighboring band distortion induced by the strong received signals. This is verified and demonstrated with extensive simulations and true RF hardware measurements.

#### General information



Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Airbus Group, Airbus Defence and Space GmbH

Contributors: Allen, M., Marttila, J., Valkama, M., Singh, S., Epp, M., Schlecker, W.

Number of pages: 8

Pages: 1361-1368

Publication date: 26 Feb 2016

#### Host publication information

Title of host publication: 2015 49th Asilomar Conference on Signals, Systems and Computers

Publisher: IEEE COMPUTER SOCIETY PRESS

ISBN (Print): 9781467385763

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

Keywords: Direct-conversion receiver, interference cancellation, nonlinear distortion, nonlinearity modeling, radar

Electronic versions:

Asilomar2015\_postprint

DOIs:

10.1109/ACSSC.2015.7421365

URLs:

<http://urn.fi/URN:NBN:fi:tty-201608034373>

#### Bibliographical note

EXT="Singh, Simran"

Source: Scopus

Source ID: 84969781278

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Innovative e-Tourism Services on Top of Geo2Tag LBS Platform

Location based and geo-context aware services form the new fast growing domain of commercially successful ICT solutions. These services play the key role in IoT scenarios and development of smart spaces and proactive solutions. One of the most attractive application areas is e-Tourism. More people can afford travelling and over the last few decades we see continues growth of the tourist activity. At the same time we see huge increase of demand both in quantity and quality of tourist services. Many experts foresee that this growth cannot any longer be fulfilled by applying traditional approaches. Similarly to the change in tickets and hotel booking, it is expected that soon we will witness major transformation in the whole industry towards e-Tourism driven market, where roles of traditional service providers, e.g., tourist agents, guides, will disappear or seriously changed. Internet of Things (IoT) is an integral part of the Future Internet ecosystem that has major impact on development of e-Tourism services. IoT provides an infrastructure to uniquely identify and link physical objects with virtual representations. As a result any physical object can have virtual reflection in the service space. This gives an opportunity to replace actions on physical objects by operations on their virtual reflections, which is faster, cheaper and more comfortable for the user. In this paper we summarize our research in the field, share ideas of innovative e-Tourism services and present Geo2Tag LBS platform that allows easy and fast development of such services.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, FRUCT Oy, Laboratory of Information Science and Semantic Technologies, ITMO University

Contributors: Balandina, E., Balandin, S., Koucheryavy, Y., Mouromtsev, D.

Number of pages: 8

Pages: 752-759

Publication date: 5 Feb 2016

#### Host publication information

Title of host publication: Proceedings - 11th International Conference on Signal-Image Technology and Internet-Based Systems, SITIS 2015

Publisher: IEEE

ISBN (Print): 9781467397216

ASJC Scopus subject areas: Signal Processing, Computer Networks and Communications, Information Systems

Keywords: e-Tourism, Geo2Tag, ICT for Cultural Heritage, Internet of Things, IoT, Tourist services, Use Cases

DOIs:

10.1109/SITIS.2015.11

#### Bibliographical note

EXT="Balandin, Sergey"

Source: Scopus

Source ID: 84966375788

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Accurate depth estimation from a sequence of monocular images supported by proprioceptive sensors**

This paper describes an extended Kalman filter based algorithm for fusion of monocular vision measurements, inertial rate sensor measurements, and camera motion. The motion of the camera between successive images generates a baseline for range computations by triangulation. The recursive estimation algorithm is based on extended Kalman filtering. The depth estimation accuracy is strongly affected by mutual observer and feature point geometry, measurement accuracy of observer motion parameters and line of sight to a feature point. The simulation study investigates how the estimation accuracy is affected by the following parameters: linear and angular velocity measurement errors, camera noise, and observer path. These results draw requirements to the instrumentation and observation scenarios. It was found that under favorable conditions the error in distance estimation does not exceed 2% of the distance to a feature point.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Automation Science and Engineering, Research area: Dynamic Systems, Research area: Measurement Technology and Process Control, Research group: Positioning

Contributors: Davidson, P., Raunio, J. P., Piché, R.

Number of pages: 9

Pages: 249-257

Publication date: 2016

#### **Host publication information**

Title of host publication: 23rd Saint Petersburg International Conference on Integrated Navigation Systems, ICINS 2016 - Proceedings

Publisher: State Research Center of the Russian Federation

ISBN (Electronic): 9785919950370

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering, Information Systems

Keywords: Computer vision, Gyroscope, IMU, Odometer, Structure from motion

URLs:

<http://www.scopus.com/inward/record.url?scp=84979573597&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84979573597

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Computer vision aided navigation systems**

The paper considers the possible use of computer vision systems for INS aiding. Two methods of navigation data obtaining from the image sequence are analyzed. The first method uses the features of architectural elements in indoor and urban conditions for generation of object attitude parameters. The second method is based on extraction of general features in the image and is more widely applied. Besides the orientation parameters, the second method estimates the object displacement, and thus can be used as visual odometry technique. The described algorithms can be used to develop small-sized MEMS navigation systems efficiently operating in urban conditions.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Automation Science and Engineering, Research group: Positioning, ITMO University

Contributors: Davidson, P., Merkulova, I.

Number of pages: 3

Pages: 560-562

Publication date: 2016

#### **Host publication information**

Title of host publication: 23rd Saint Petersburg International Conference on Integrated Navigation Systems, ICINS 2016 - Proceedings

Publisher: State Research Center of the Russian Federation

ISBN (Electronic): 9785919950370

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering, Information Systems

Keywords: Camera, Computer vision, Data fusion, Image processing, Inertial system, Orientation

URLs:

<http://www.scopus.com/inward/record.url?scp=84979499890&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84979499890

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **OpenCL Programmable Exposed Datapath High Performance Low-Power Image Signal Processor**

Sophisticated computational imaging algorithms require both high performance and good energy-efficiency when executed on mobile devices. Recent trend has been to exploit the abundant data-level parallelism found in general purpose programmable GPUs. However, for low-power mobile use cases, generic GPUs consume excessive amounts of power. This paper proposes a programmable computational imaging processor with 16-bit half-precision SIMD floating point vector processing capabilities combined with power efficiency of an exposed datapath. In comparison to traditional VLIW architectures with similar computational resources, the exposed datapath reduces the register file traffic and complexity. These and the specific optimizations enabled by the explicit programming model enable extremely good power-performance. When synthesized on a 28nm ASIC technology, the accelerator consumes 71mW of power while running a state-of-the-art denoising algorithm, and occupies only 0.2mm<sup>2</sup> of chip area. For the algorithm, energy usage per frame is 7mJ, which is 10x less than the best found GPU-based implementation.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Pervasive Computing, Research area: Computer engineering, Noiseless Imaging Oy Ltd

Contributors: Multanen, J., Kultala, H., Koskela, M., Viitanen, T., Jääskeläinen, P., Takala, J., Danielyan, A., Cruz, C.

Number of pages: 6

Publication date: 2016

#### **Host publication information**

Title of host publication: 2016 IEEE Nordic Circuits and Systems Conference (NORCAS)

Publisher: IEEE

ISBN (Electronic): 978-1-5090-1095-0

ASJC Scopus subject areas: Hardware and Architecture, Signal Processing

Electronic versions:

OpenCLProgrammableExposedDatapath

DOIs:

10.1109/NORCHIP.2016.7792906

URLs:

<http://urn.fi/URN:NBN:fi:tty-201702061098>

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **BM3D image denoising using heterogeneous computing platforms**

Noise reduction is often performed at an early stage of the image processing path. In order to keep the processing delays small in different computing platforms, it is important that the noise reduction is performed swiftly. In this paper, the block-matching and three-dimensional filtering (BM3D) denoising algorithm is implemented on heterogeneous computing platforms using OpenCL and CUDA frameworks. To our knowledge, these implementations are the first successful open source attempts to use GPU computation for BM3D denoising. The presented GPU implementations are up to 7.5 times faster than their respective CPU implementations. At the same time, the experiments illustrate general design challenges in using massively parallel processing platforms for the calculation of complex imaging algorithms.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Univ of Oulu, Center for Machine Vision Research

Contributors: Sarjanoja, S., Boutellier, J., Hannuksela, J.

Publication date: 28 Dec 2015

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Publisher: IEEE COMPUTER SOCIETY PRESS

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ISBN (Electronic): 9791092279108

ASJC Scopus subject areas: Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: Image denoising, Mobile computing, Parallel algorithms, Parallel processing

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Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Whole-cell morphological properties of neurons constrain the nonrandom features of network connectivity**

We addressed the principles of micro-level organization of neuronal circuits and explored how the neuronal morphology constrains this organization. Several studies have demonstrated the non-trivial properties of the network connectivity using in vitro recordings from multiple neurons [1, 2, 3], yet it is unclear to what extent this structure reflects reorganization caused by synaptic plasticity, and what is imposed by the morphological constraints. Two recent articles explored this issue using the simulated neural circuits and demonstrated the specific structural properties in those circuits [4, 5]. We analyzed a model that emphasizes the role of single-cell morphology, a homogeneous population of neurons in a planar space without boundaries. Each neuron is composed of two displaced neurite fields defined on the limited support. A neurite field describes the likelihood of finding a neurite segment at a certain point in the plane. Using a proximity criterion (Peters' rule) the expected number of potential synapses is estimated between each pair of neurons. Alternatively, this number can be estimated from the realistic morphology of a simulated neuron, or from the morphologies reconstructed from in vitro/in vivo recordings. The number of potential synapses depends on the axon-dendrite distance, which leads to a definition of the expected radius. An axon-dendrite pair that is expected to form at least one synapse must be on a distance not larger than the effective radius. All considered statistical measures of network connectivity are expressed as the functions of the effective radius normalized with the neuron size. In this study, we considered the standard graph theoretic measures of network connectivity, the motif counts, clustering coefficient, path length, and small-world coefficient. It has been demonstrated that they have a significant impact on the population activity in simulated networks [6]. Changing the normalized effective radius from small (<0.3) to big (>10) we vary the network properties between the two extremes. For the small values of the effective radius, the networks favor unidirectional connections and sparse local connectivity. The clustering coefficient and the path length are similar to those obtained in uniform random networks, i.e. in the networks independent of topology. For the large values of the effective radius, the local connectivity is dense with the majority of bidirectional connections. As the normalized effective radius increases, the clustering coefficient increases towards the values obtained for the networks with dominant local connectivity, while the path length remains close to the one of the uniform random networks. The normalized effective radius on the interval 1-2, provides the biggest variability of connectivity patterns and the optimized properties relevant for the information transfer. Conclusions: We present a theoretical framework that relates neuromorphology with the connectivity in neuronal circuits, and that can be solved analytically. The normalized effective radius was found to be the key morphological property that dominantly affects considered connectivity measures. By tuning it we can obtain the networks with the biggest variability of local connectivity patterns. At the same time, those networks acquire the key characteristics of the small-world networks, known to optimize the information transfer.

### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Faculty of Biomedical Sciences and Engineering

Contributors: Acimovic, J., Mäki-Marttunen, T. M., Linne, M.

Number of pages: 1

Pages: P:O7

Publication date: 4 Dec 2015

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Place of publication: Prague

Publisher: BioMed Central

Editors: Cymbalyuk, G., Burkitt, A.

Article number: O7

ASJC Scopus subject areas: Neuroscience (miscellaneous), Signal Processing

Keywords: network connectivity, clustering coefficient, effective radius, neuronal circuit, connectivity pattern, morphology, dendrites, Neurite density field, neurites

URLs:

<https://bmcneurosci.biomedcentral.com/articles/supplements/volume-16-supplement-1>

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Programming graphics processing units in the RVC-CAL dataflow language**

The interest towards programming of streaming applications using dataflow models of computation has been increasing steadily in the recent years. Among the numerous dataflow formalisms, the ISO-standardized RVC-CAL dataflow

language has offered a solid basis for programming tool development and research. To this date RVC-CAL programming tools have enabled transforming dataflow programs into concurrent executables for multicore processors, as well as for generating synthesizable hardware descriptions. In this paper it is shown how the RVC-CAL dataflow language can be used for programming graphics processing units (GPUs) with high efficiency. Considering the processing architectures of recent mobile and desktop computing devices, this advance is of high importance, as most consumer devices contain a graphics processing unit nowadays. To evaluate the proposed solution, the paper presents a video processing application case study. At best, the solution is shown to provide a speedup of 42× over single-threaded CPU execution.

#### **General information**

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Organisations: Signal Processing Research Community (SPRC), Dept. of Computer Science and Engineering, Univ of Oulu

Contributors: Boutellier, J., Nyländen, T.

Publication date: 2 Dec 2015

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Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 7344994

ISBN (Electronic): 9781467396042

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics, Hardware and Architecture

Keywords: Dataflow computing, design automation, parallel processing

DOIs:

10.1109/SiPS.2015.7344994

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<http://www.scopus.com/inward/record.url?scp=84958191208&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84958191208

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### **Cosparse dictionary learning for the orthogonal case**

Dictionary learning is usually approached by looking at the support of the sparse representations. Recent years have shown results in dictionary improvement by investigating the cosupport via the analysis-based cosparse model. In this paper we present a new cosparse learning algorithm for orthogonal dictionary blocks that provides significant dictionary recovery improvements and representation error shrinkage. Furthermore, we show the beneficial effects of using this algorithm inside existing methods based on building the dictionary as a structured union of orthonormal bases.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Signal Processing Research Community (SPRC), University Politehnica of Bucharest

Contributors: Irofti, P., Dumitrescu, B.

Number of pages: 5

Pages: 343-347

Publication date: 5 Nov 2015

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Publisher: IEEE

ISBN (Print): 9781479984817

ASJC Scopus subject areas: Control and Systems Engineering, Artificial Intelligence, Information Systems, Signal Processing

Keywords: cosparse, dictionary design, orthogonal blocks, sparse representation

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Source: Scopus

Source ID: 84957825116

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **The effect of region of interest size on textural parameters**

Texture analysis provides quantitative information describing the properties of a digital image. The value of texture analysis has been tested in various medical applications, using mostly magnetic resonance images because of the amount of information the method is capable to provide. However, there exists no certain practice to define the region of interest (ROI) within the texture parameters are calculated. Many parameters seem to be dependent on the ROI size. We studied the effect of the ROI size with magnetic resonance head images from 64 healthy adults and artificial noise images. According to our results, ROI size has a significant effect on the computed value of several second-order texture features. We conclude that comparisons of different size ROIs will therefore lead to falsely optimistic classification between analyzed tissues.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, Research group: Quantative medical imaging , Integrated Technologies for Tissue Engineering Research (ITTE), Tampere University Hospital, Department of Radiology

Contributors: Sikiö, M., Holli-Helenius, K. K., Ryymin, P., Dastidar, P., Eskola, H., Harrison, L.

Number of pages: 5

Pages: 149-153

Publication date: 23 Oct 2015

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Publisher: IEEE

ISBN (Electronic): 9781467380324

ASJC Scopus subject areas: Signal Processing, Computer Vision and Pattern Recognition

Keywords: magnetic resonance imaging, random pattern, region of interest, size, texture analysis

DOIs:

10.1109/ISPA.2015.7306049

#### **Bibliographical note**

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EXT="Sikiö, Minna"

Source: Scopus

Source ID: 84978524965

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **MOBILE3DTV: Content delivery optimization over DVB-H system**

Mobile TV has recently received a lot of attention worldwide with the advances in technologies such as Digital Multimedia Broadcasting (DMB), Digital Video Broadcasting - Handheld (DVB-H) and MediaFLO. On the other hand 3DTV is a new approach to watching TV, introducing the third dimension for a more realistic and interactive experience. With the merge of these two technologies it will be possible to have 3DTV products and services based on portable platforms with switchable 2D/3D autostereoscopic displays. The paper presents the European Mobile3DTV project approach toward achieving such a merge. The project specifically addresses the mobile 3DTV delivery over DVB-H system. It develops a technology demonstration system comprising suitable stereo-video content-creation techniques; efficient, scalable and flexible stereo-video encoders with error resilience and error-concealment capabilities, tailored for robust transmission over DVB-H; and also the corresponding stereo-video decoders and players working on a portable terminal device equipped with an autostereoscopic display.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: 3D MEDIA, Signal Processing Research Community (SPRC), Middle East Technical Univ.

Contributors: Akar, G. B., Gotchev, A.

Publication date: 15 Sep 2015

#### **Host publication information**

Title of host publication: SMPTE International Conference on Stereoscopic 3D for Media and Entertainment

Publisher: SMPTE

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ASJC Scopus subject areas: Signal Processing, Media Technology

Keywords: DVB-H, error resilient transmission, Mobile3DTV

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Source: Scopus

Source ID: 84978435566

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **The extended one-dimensional discrete phase retrieval problem**

It has been known for decades that the iterative methods are perhaps the most popular approaches to solve the phase retrieval problem. Unfortunately the iterative methods often stagnate. This happens also in the case of the 1-D Discrete Phase Retrieval (1-D DPhR) problem. Recently it has been shown that some requirements in the input magnitude data might be one of the reasons why the direct method cannot solve the 1-D DPhR Problem. In this work we present some difficulties that can be encountered when one has to implement the iterative method for finding a solution of 1-D DPhR problem. We shall formulate the extended form of 1-D DPhR problem. Simulations indicate the conjecture to be true.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Algebraic and Algorithmic Methods in Signal Processing AAMSP, Signal Processing Research Community (SPRC), FETTI, Technical University of Cluj-Napoca

Contributors: Rusu, C., Astola, J.

Publication date: 14 Aug 2015

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ASJC Scopus subject areas: Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

DOIs:

10.1109/ISSCS.2015.7204029

#### **Bibliographical note**

EXT="Rusu, Corneliu"

Source: Scopus

Source ID: 84955586971

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Enhancing class discrimination in Kernel Discriminant Analysis**

In this paper, we propose an optimization scheme aiming at optimal nonlinear data projection, in terms of Fisher ratio maximization. To this end, we formulate an iterative optimization scheme consisting of two processing steps: optimal data projection calculation and optimal class representation determination. Compared to the standard approach employing the class mean vectors for class representation, the proposed optimization scheme increases class discrimination in the reduced-dimensionality feature space. We evaluate the proposed method in standard classification problems, as well as on the classification of human actions and face, and show that it is able to achieve better generalization performance, when compared to the standard approach.

#### **General information**

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MoE publication type: A4 Article in a conference publication

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

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ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: Kernel Discriminant Analysis, Nonlinear data projection, Optimized Class Representation

DOIs:

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Source: Scopus

Source ID: 84946088724

### **Exploiting subclass information in one-class support vector machine for video summarization**

In this paper, we propose a method for video summarization based on human activity description. We formulate this problem as the one of automatic video segment selection based on a learning process that employs salient video segment paradigms. For this one-class classification problem, we introduce a novel variant of the One-Class Support Vector Machine (OC-SVM) classifier that exploits subclass information in the OC-SVM optimization problem, in order to jointly minimize the data dispersion within each subclass and determine the optimal decision function. We evaluate the proposed approach in three Hollywood movies, where the performance of the proposed SOC-SVM algorithm is compared with that of the OC-SVM. Experimental results denote that the proposed approach is able to outperform OC-SVM-based video segment selection.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki

Contributors: Mygdalis, V., Iosifidis, A., Tefas, A., Pitas, I.

Number of pages: 5

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ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: One class classification, Subclass One-Class SVM, Supervised Video Summarization

DOIs:

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Source ID: 84945586271

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Low-complexity robust DOA estimation**

We propose a low complexity method for estimating direction of arrival (DOA) when the positions of the array sensors are affected by errors with known magnitude bound. This robust DOA method is based on solving an optimization problem whose solution is obtained in two stages. First, the problem is relaxed and the corresponding power estimation has an expression similar to that of standard beamforming. If the relaxed solution does not satisfy the magnitude bound, an approximation is made by projection. Unlike other robust DOA methods, no eigenvalue decomposition is necessary and the complexity is similar to that of MVDR. For low and medium SNR, the proposed method competes well with more complex methods and is clearly better than MVDR.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Algebraic and Algorithmic Methods in Signal Processing AAMSP, Signal Processing Research Community (SPRC), Dept. of Automatic Control and Computers, University Politehnica of Bucharest

Contributors: Dumitrescu, B., Rusu, C., Tabus, I., Astola, J.

Number of pages: 5

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ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: direction of arrival, optimization, robustness, spectral power density

DOIs:

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Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Similarity induced group sparsity for non-negative matrix factorisation**

Non-negative matrix factorisations are used in several branches of signal processing and data analysis for separation and classification. Sparsity constraints are commonly set on the model to promote discovery of a small number of dominant patterns. In group sparse models, atoms considered to belong to a consistent group are permitted to activate together, while activations across groups are suppressed, reducing the number of simultaneously active sources or other structures. Whereas most group sparse models require explicit division of atoms into separate groups without addressing their mutual relations, we propose a constraint that permits dynamic relationships between atoms or groups, based on any defined distance measure. The resulting solutions promote approximation with components considered similar to each other. Evaluation results are shown for speech enhancement and noise robust speech and speaker recognition.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Audio research group, Signal Processing Research Community (SPRC), Aalto University

Contributors: Hurmalainen, A., Saeidi, R., Virtanen, T.

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Pages: 4425-4429

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Publisher: The Institute of Electrical and Electronics Engineers, Inc.

ISBN (Print): 9781467369978

ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: group sparsity, non-negative matrix factorization, sparse representations, speaker recognition, speech recognition

DOIs:

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Source: Scopus

Source ID: 84946089342

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Collaborative filtering based on group coordinates for smoothing and directional sharpening**

Groups of mutually similar image blocks are the key element in nonlocal image processing. In this work, the spatial coordinates of grouped blocks are leveraged in two distinct parts of the transform-domain collaborative filtering within the BM3D algorithm. First, we introduce an adaptive 1-D transform for 3-D collaborative filtering based on sampling 2-D smooth functions at the positions of grouped blocks. This adaptive transform is applied for improved decorrelation of the 2-D spectra of the grouped blocks. Second, we propose a directional sharpening procedure whose strength varies adaptively according to the relative orientation of the transform basis functions with respect to the group coordinates. Experiments confirm the efficacy of the proposed adaptations, for denoising as well as for sharpening of noisy images.

#### **General information**

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MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Signal and Image Restoration-RST, Research area: Signal and Information Processing, Signal Processing Research Community (SPRC)

Contributors: Azzari, L., Foi, A.

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Publisher: IEEE

ISBN (Print): 9781467369978

ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: adaptive transforms, BM3D, collaborative filtering, denoising, sharpening

Electronic versions:

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DOIs:

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URLs:

<http://urn.fi/URN:NBN:fi:tty-201704041247>

Source: Scopus

Source ID: 84946074037

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Exemplar-based speech enhancement for deep neural network based automatic speech recognition**

Deep neural network (DNN) based acoustic modelling has been successfully used for a variety of automatic speech recognition (ASR) tasks, thanks to its ability to learn higher-level information using multiple hidden layers. This paper investigates the recently proposed exemplar-based speech enhancement technique using coupled dictionaries as a pre-processing stage for DNN-based systems. In this setting, the noisy speech is decomposed as a weighted sum of atoms in an input dictionary containing exemplars sampled from a domain of choice, and the resulting weights are applied to a coupled output dictionary containing exemplars sampled in the short-time Fourier transform (STFT) domain to directly obtain the speech and noise estimates for speech enhancement. In this work, settings using input dictionary of exemplars sampled from the STFT, Mel-integrated magnitude STFT and modulation envelope spectra are evaluated. Experiments performed on the AURORA-4 database revealed that these pre-processing stages can improve the performance of the DNN-HMM-based ASR systems with both clean and multi-condition training.

#### **General information**

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MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Audio research group, Signal Processing Research Community (SPRC), KU Leuven

Contributors: Baby, D., Gemmeke, J. F., Virtanen, T., Van Hamme, H.

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Publisher: The Institute of Electrical and Electronics Engineers, Inc.

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ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: coupled dictionaries, deep neural networks, modulation envelope, non-negative matrix factorisation, speech enhancement

DOIs:

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Source ID: 84946079930

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Low-Latency Sound-Source-Separation using Non-Negative Matrix Factorisation with Coupled Analysis and Synthesis Dictionaries**

For real-time or close to real-time applications, sound source separation can be performed on-line, where new frames of incoming data for a mixture signal are processed as they arrive, at very low delay. We propose an approach which generates the separation filters for short synthesis frames to achieve low latency source separation, based on a compositional model mixture of the audio to be separated. Filter parameters are derived from a longer temporal context than the current processing frame through use of a longer analysis frame. A pair of dictionaries are used, one for analysis and one for reconstruction. With this approach we are able to increase separation performance at low latencies whilst retaining the low-latency provided by the use of short synthesis frames. The proposed data handling scheme and parameters can be adjusted to achieve real-time performance, given sufficient computational power. Low-latency output allows a human listener to use the results of such a separation scheme directly, without a perceptible delay. With the proposed method, separated source-to-distortion ratios (SDRs) can be improved by over 1 dB for latencies below 20 ms, without any affect on latency.

#### **General information**

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Organisations: Department of Signal Processing, Research group: Audio research group, Signal Processing Research Community (SPRC)

Contributors: Barker, T., Virtanen, T., Pontoppidan, N. H.  
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Pages: 241-245  
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ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering  
Keywords: low-latency, NMF, Non-negative matrix factorisation, real-time, source separation  
DOIs:  
10.1109/ICASSP.2015.7177968  
URLs:  
[http://www.cs.tut.fi/~barkert/Publications\\_files/ICASSP2015\\_TomBarker\\_Preprint.pdf](http://www.cs.tut.fi/~barkert/Publications_files/ICASSP2015_TomBarker_Preprint.pdf) (Preprint)  
Source: Scopus  
Source ID: 84946043719  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Ambient energy harvesting from a two-way talk radio for flexible wearable devices utilizing inkjet printing masking

In this paper, the design, on a flexible LCP substrate, and fabrication process of a wearable circuit harvesting the ambient energy emitted from a two-way radio is discussed in detail. The circuit is fabricated through the combination of circuit traces made with masking utilizing inkjet printing technology and lumped circuit components. The input power for the RF-DC conversion circuit is analytically computed from the measured S-parameters of the Tx-Rx propagation channel. A maximum output power of 43.2mW with the RF-DC conversion efficiency of 82.5% and open-circuit voltage of 17.87 V is achieved with an E-field energy harvester placed 7cm away from an off-the-shelf 1W two-way talk radio.

#### General information

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Sensing Systems for Wireless Medicine (MediSense), Georgia Institute of Technology, School of Electrical and Computer Engineering  
Contributors: Bito, J., Hester, J. G., Tentzeris, M. M.  
Publication date: 24 Jul 2015

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Publisher: Institute of Electrical and Electronics Engineers Inc.  
Article number: 7167079  
ISBN (Electronic): 9781479982752  
ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering  
Keywords: Energy harvesting, Flexible, Inkjet printing, Wearable  
DOIs:  
10.1109/MWSYM.2015.7167079  
URLs:  
<http://www.scopus.com/inward/record.url?scp=84946084387&partnerID=8YFLogxK> (Link to publication in Scopus)  
Source: Scopus  
Source ID: 84946084387  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### A flexible hybrid printed RF energy harvester utilizing catalyst-based copper printing technologies for far-field RF energy harvesting applications

In this paper, the design of a novel flexible RF energy harvester utilizing hybrid printed electronics technology is presented for the first time. The proposed RF energy harvester operates at UHF RFID band (868 MHz ~ 915 MHz) for far-field RF energy harvesting applications. A concept of hybrid printed electronics which takes advantage of both flexibility of low-cost printed electronics and high performances of ICs is introduced. The passive components of the RF energy harvester, such as the circuit layout and the antenna, are printed on a flexible low-cost polymer substrate utilizing a catalyst-based inkjet printing process for the fabrication of copper metallization layers. The surface-mount devices (SMDs) are soldered on the printed circuit board. The proposed approach demonstrates the feasibility of implementing low-cost flexible printed electronics for the Internet of Things (IoT) and stand-alone ('zero-power') wireless sensor platforms.

#### General information

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MoE publication type: A4 Article in a conference publication  
Organisations: Sensing Systems for Wireless Medicine (MediSense), Georgia Institute of Technology, Centre Tecnològic Telecomunicacions Catalunya (CTTC)  
Contributors: Kim, S., Bito, J., Jeong, S., Georgiadis, A., Tentzeris, M. M.  
Publication date: 24 Jul 2015

#### Host publication information

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Article number: 7166723  
ISBN (Electronic): 9781479982752  
ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering  
Keywords: Catalyst-based inkjet printing, charge pump, hybrid printed electronics, printed copper, RF energy harvester, RF-DC converter, wireless power transfer  
DOIs:  
10.1109/MWSYM.2015.7166723  
URLs:  
<http://www.scopus.com/inward/record.url?scp=84946035832&partnerID=8YFLogxK> (Link to publication in Scopus)  
Source: Scopus  
Source ID: 84946035832  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### 3D/inkjet-printed origami antennas for multi-direction RF harvesting

A system design is presented for radio frequency (RF) energy harvesting on wireless sensor network (WSN) nodes, where all electronics reside inside a 3D structure and the antennas lie on the surfaces of it. Additive manufacturing techniques are used for the packaging and antenna fabrication: A 3D-printed cross-shaped structure is built that folds to a cuboid in an 'origami' fashion and retains its shape at room temperature. Inkjet printing is used to directly fabricate antennas on the surfaces of the 3D-printed plastic, enabling a fully additive manufacturing of the structure. Multiple antennas on the cube's surfaces can be used for RF energy harvesting of signals arriving from totally orthogonal directions, with the use of an appropriate harvester. The system modules (cube, antenna, harvester) are described and characterized, offering a proof-of-concept for the combination of fabrication techniques to build systems for demanding RF applications.

#### General information

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Sensing Systems for Wireless Medicine (MediSense), Georgia Institute of Technology, School of Electrical and Computer Engineering, Centre Tecnològic de Telecomunicacions de Catalunya, Georgia Institute of Technology  
Contributors: Kimionis, J., Georgiadis, A., Isakov, M., Qi, H. J., Tentzeris, M. M.  
Publication date: 24 Jul 2015

#### Host publication information

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Publisher: Institute of Electrical and Electronics Engineers Inc.  
Article number: 7166878  
ISBN (Electronic): 9781479982752  
ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering  
Keywords: 3D printing, additive manufacturing, inkjet printing, multiple antennas, RF energy harvesting  
DOIs:  
10.1109/MWSYM.2015.7166878  
URLs:  
<http://www.scopus.com/inward/record.url?scp=84946068129&partnerID=8YFLogxK> (Link to publication in Scopus)  
Source: Scopus  
Source ID: 84946068129  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Additively manufactured multilayer high performance RF passive components on cellulose substrates for internet-of-things electronic circuits

This paper demonstrates the feasibility to manufacture high performance radio-frequency passive components on cellulose substrates by exploiting two novel technologies: the vertically integrated inkjet printing and the copper laminate method. Both processes are substrate independent and thus suitable for fabricating circuits on paper as well; moreover, in a future perspective, they can be easily combined together in order to exploit their complementarity. Passive components such as capacitors and inductors, with Qs up to 22, never registered before on cellulose substrates, and Self-Resonant-Frequency (SRF) up to 4 GHz are described. The obtained values of the capacitance and inductance per unit area are 0.8

pF/mm<sup>2</sup> and 43 nH/mm<sup>2</sup>, respectively.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Sensing Systems for Wireless Medicine (MediSense), University of Perugia, Georgia Institute of Technology, School of Electrical and Computer Engineering

Contributors: Mariotti, C., Cook, B. S., Alimenti, F., Roselli, L., Tentzeris, M. M.

Publication date: 24 Jul 2015

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Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 7166924

ISBN (Electronic): 9781479982752

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering

Keywords: Additive Manufacturing, Copper Laminate, Flexible Electronics, green electronics, Inkjet Printing, Internet of Things, Passives

DOIs:

10.1109/MWSYM.2015.7166924

URLs:

<http://www.scopus.com/inward/record.url?scp=84946068619&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84946068619

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Lossy-to-lossless progressive coding of depth-maps

A progressive coding method is proposed for depth-map images, where the bitstream is encoded so that one can generate many lossy versions of the original, encompassing a wide range, from very low resolution up to lossless reconstruction. The partitions into regions of the lossy versions are assumed to be nested, so that a higher resolution image is obtained by splitting some regions of a lower resolution image. The encoder transmits to the decoder information about which regions to split, the extra contour to be added for obtaining the shapes of the more refined regions, and the extra depth values needed inside each new region. The efficient encoding of the anchor points in the progressive scenario, relative to the contour points already encoded, and the depth information recovery, are the main contributions of this paper. The progressive bitstream produced by the proposed method scales well over the whole range of rates, from low rates to lossless, reaching a performance close to that of the non-progressive methods.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Algebraic and Algorithmic Methods in Signal Processing AAMSP, Research group: Signal Interpretation and Compression-SIC, Signal Processing Research Community (SPRC)

Contributors: Schioppa, I., Tabus, I.

Number of pages: 4

Pages: 1 - 4

Publication date: Jul 2015

#### Host publication information

Title of host publication: International Symposium on Signals, Circuits and Systems (ISSCS)

Place of publication: Iasi, Romania

ISBN (Print): 978-1-4673-7487-3

ASJC Scopus subject areas: Signal Processing

DOIs:

10.1109/ISSCS.2015.7203966

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Partial expansion of dataflow graphs for resource-aware scheduling of multicore signal processing systems

The complex design spaces associated with state-of-the-art, multicore signal processing systems pose significant challenges in realizing designs with high productivity and quality. The Partial Expansion Graph (PEG) implementation model was developed to help address these challenges by enabling more efficient exploration of the scheduling design space for multicore digital signal processors. The PEG allows designers and design tools to systematically adjust and adapt the amount of parallelism exposed from applications depending on the targeted platform. In this paper, we develop new algorithms for scheduling and mapping systems implemented using PEGs. Collectively, these algorithms operate in

three steps. First, the amount of data parallelism in the application graph is tuned systematically over many iterations to profit from the available cores in the target platform. Then a mapping algorithm that uses graph analysis is developed to distribute data and task parallel instances over different cores while trying to balance the load of all processing units to make use of pipeline parallelism. Finally, we use a novel technique for performance evaluation by implementing the scheduler and a customizable solution on the programmable platform. We demonstrate the utility of our PEG-based scheduling and mapping algorithms through experiments on real application models and various synthetic graphs.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering, Texas Instruments

Contributors: Zaki, G., Plishker, W., Bhattacharyya, S. S., Fruth, F.

Number of pages: 8

Pages: 385-392

Publication date: 24 Apr 2015

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Volume: 2015-April

Publisher: IEEE COMPUTER SOCIETY PRESS

Article number: 7094469

ISBN (Electronic): 9781479982974

ASJC Scopus subject areas: Signal Processing, Computer Networks and Communications

Keywords: Dataflow Graphs, Digital Signal Processing, Dynamic Scheduling, Multiprocessor Scheduling

DOIs:

10.1109/ACSSC.2014.7094469

URLs:

<http://www.scopus.com/inward/record.url?scp=84940548010&partnerID=8YFLogxK> (Link to publication in Scopus)

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Lossless compression of regions-of-interest from retinal images

This paper presents a lossless compression method performing separately the compression of the vessels and of the remaining part of eye fundus in retinal images. Retinal images contain valuable information sources for several distinct medical diagnosis tasks, where the features of interest can be e.g. the cotton wool spots in the eye fundus, or the volume of the vessels over concentric circular regions. It is assumed that one of the existent segmentation methods provided the segmentation of the vessels. The proposed compression method transmits losslessly the segmentation image, and then transmits the eye fundus part, or the vessels image, or both, conditional on the vessels segmentation. The independent compression of the two color image segments is performed using a sparse predictive method. Experiments are provided over a database of retinal images containing manual and estimated segmentations. The codelength of encoding the overall image, including the segmentation and the image segments, proves to be better than the codelength for the entire image obtained by JPEG2000 and other publicly available compressors.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Signal Interpretation and Compression-SIC, Signal Processing Research Community (SPRC)

Contributors: Hukkanen, J., Astola, P., Tabus, I.

Publication date: 22 Jan 2015

#### Host publication information

Title of host publication: EUVIP 2014 - 5th European Workshop on Visual Information Processing

Publisher: The Institute of Electrical and Electronics Engineers, Inc.

ISBN (Print): 9781479945726

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Information Systems, Signal Processing

Keywords: lossless compression, region of interest, retinal images, sparse prediction

DOIs:

10.1109/EUVIP.2014.7018394

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Classification of iPSC colony images using hierarchical strategies with support vector machines

In this preliminary research we examine the suitability of hierarchical strategies of multi-class support vector machines for classification of induced pluripotent stem cell (iPSC) colony images. The iPSC technology gives incredible possibilities for safe and patient specific drug therapy without any ethical problems. However, growing of iPSCs is a sensitive process and

abnormalities may occur during the growing process. These abnormalities need to be recognized and the problem returns to image classification. We have a collection of 80 iPSC colony images where each one of the images is pre-labeled by an expert to class bad, good or semigood. We use intensity histograms as features for classification and we evaluate histograms from the whole image and the colony area only having two datasets. We perform two feature reduction procedures for both datasets. In classification we examine how different hierarchical constructions effect the classification. We perform thorough evaluation and the best accuracy was around 54% obtained with the linear kernel function. Between different hierarchical structures, in many cases there are no significant changes in results. As a result, intensity histograms are a good baseline for the classification of iPSC colony images but more sophisticated feature extraction and reduction methods together with other classification methods need to be researched in future.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, Research group: Computational Biophysics and Imaging Group, BioMediTech, Augmented Human Activities (AHA), Integrated Technologies for Tissue Engineering Research (ITTE), University of Tampere, Univ Tampere, University of Tampere, BioMediTech, BMT FM5

Contributors: Joutsijoki, H., Rasku, J., Haponen, M., Baldin, I., Gizatdinova, Y., Paci, M., Saarikoski, J., Varpa, K., Siirtola, H., Ávalos-Salguero, J., Iltanen, K., Laurikkala, J., Penttinen, K., Hyttinen, J., Aalto-Setälä, K., Juhola, M.

Number of pages: 7

Pages: 86-92

Publication date: 13 Jan 2015

#### **Host publication information**

Title of host publication: IEEE SSCI 2014 - 2014 IEEE Symposium Series on Computational Intelligence - CIDM 2014: 2014 IEEE Symposium on Computational Intelligence and Data Mining, Proceedings

Publisher: The Institute of Electrical and Electronics Engineers, Inc.

Article number: 7008152

ISBN (Print): 9781479945191

ASJC Scopus subject areas: Artificial Intelligence, Information Systems, Signal Processing, Software

DOIs:

10.1109/CIDM.2014.7008152

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### **Human action recognition in stereoscopic videos based on bag of features and disparity pyramids**

In this paper, we propose a method for human action recognition in unconstrained environments based on stereoscopic videos. We describe a video representation scheme that exploits the enriched visual and disparity information that is available for such data. Each stereoscopic video is represented by multiple vectors, evaluated on video locations corresponding to different disparity zones. By using these vectors, multiple action descriptions can be determined that either correspond to specific disparity zones, or combine information appearing in different disparity zones in the classification phase. Experimental results denote that the proposed approach enhances action classification performance, when compared to the standard approach, and achieves state-of-the-art performance on the Hollywood 3D database designed for the recognition of complex actions in unconstrained environments.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Nikolaidis, N., Pitas, I.

Number of pages: 5

Pages: 1317-1321

Publication date: 10 Nov 2014

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Publisher: European Signal Processing Conference, EUSIPCO

ISBN (Print): 9780992862619

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: Bag of Features, Disparity Pyramids, Human Action Recognition, Stereoscopic Videos

Source: Scopus

Source ID: 84911920535

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### **GPU parallel implementation of the approximate K-SVD algorithm using OpenCL**

Training dictionaries for sparse representations is a time consuming task, due to the large size of the data involved and to the complexity of the training algorithms. We investigate a parallel version of the approximate K-SVD algorithm, where

multiple atoms are updated simultaneously, and implement it using OpenCL, for execution on graphics processing units (GPU). This not only allows reducing the execution time with respect to the standard sequential version, but also gives dictionaries with which the training data are better approximated. We present numerical evidence supporting this somewhat surprising conclusion and discuss in detail several implementation choices and difficulties.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: SGN-SPAG, Signal Processing Research Community (SPRC)

Contributors: Irofti, P., Dumitrescu, B.

Number of pages: 5

Pages: 271-275

Publication date: 10 Nov 2014

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Title of host publication: 2014 Proceedings of the 22nd European Signal Processing Conference (EUSIPCO)

Publisher: European Signal Processing Conference, EUSIPCO

ISBN (Print): 9780992862619

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: dictionary design, GPU, OpenCL, parallel algorithm, sparse representation

URLs:

<http://www.scopus.com/inward/record.url?scp=84911933138&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84911933138

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Radar micro-Doppler feature extraction using the Singular Value Decomposition

The micro-Doppler spectrogram depends on parts of a target moving and rotating in addition to the main body motion (e.g., spinning rotor blades) and is thus characteristic for the type of target. In this study, the micro-Doppler spectrogram is exploited to distinguish between birds and small unmanned aerial vehicles (UAVs). The focus hereby is on micro-Doppler features enabling fast classification of birds and mini-UAVs. In a second classification step, it is desired to exploit micro-Doppler features to further characterize the type of UAV, e.g., fixed-wing vs. rotary-wing. In this paper, potentially robust features are discussed supporting the first classification step, i.e., separation of birds and UAVs. The Singular Value Decomposition seems a powerful tool to extract such features, since the information content of the micro-Doppler spectrogram is preserved in the singular vectors. In the paper, some examples of micro-Doppler feature extraction via Singular Value Decomposition are given.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, TNO, Thales Nederland B.V.

Contributors: De Wit, J. J. M., Harmanny, R. I. A., Molchanov, P.

Publication date: 12 Mar 2014

#### Host publication information

Title of host publication: 2014 International Radar Conference, Radar 2014

Publisher: The Institute of Electrical and Electronics Engineers, Inc.

ISBN (Print): 9781479941957

ASJC Scopus subject areas: Computer Science Applications, Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering

Keywords: classification, micro-Doppler signature, mini-UAVs, radar, singular value decomposition, time-frequency analysis

DOIs:

10.1109/RADAR.2014.7060268

Source: Scopus

Source ID: 84946690619

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Compressed video quality assessment with modified MSE

A method to adjust the mean-squared-errors (MSE) value for coded video quality assessment is investigated in this work by incorporating subjective human visual experience. First, we propose a linear model between the mean opinion score (MOS) and a logarithmic function of the MSE value of coded video under a range of coding rates. This model is validated by experimental data. With further simplification, this model contains only one parameter to be determined by video characteristics. Next, we adopt a machine learning method to learn this parameter. Specifically, we select features to



classify video content into groups, where videos in each group are more homogeneous in their characteristics. Then, a proper model parameter can be trained and predicted within each video group. Experimental results on a coded video database are given to demonstrate the effectiveness of the proposed algorithm.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, University of Southern California

Contributors: Hu, S., Jin, L., Kuo, C. J.

Publication date: 12 Feb 2014

#### Host publication information

Title of host publication: 2014 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference, APSIPA 2014

Publisher: The Institute of Electrical and Electronics Engineers, Inc.

ISBN (Print): 9786163618238

ASJC Scopus subject areas: Signal Processing, Information Systems

DOIs:

10.1109/APSIPA.2014.7041643

Source: Scopus

Source ID: 84949924016

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Just-in-time scheduling techniques for multicore signal processing systems

This paper introduces a novel multicore scheduling method that leverages a parameterized dataflow Model of Computation (MoC). This method, which we have named Just-In-Time Multicore Scheduling (JIT-MS), aims to efficiently schedule Parameterized and Interfaced Synchronous DataFlow (PiSDF) graphs on multicore architectures. This method exploits features of PiSDF to find locally static regions that exhibit predictable communications. This paper uses a multicore signal processing benchmark to demonstrate that the JIT-MS scheduler can exploit more parallelism than a conventional multicore task scheduler based on task creation and dispatch. Experimental results of the JIT-MS on an 8-core Texas Instruments Keystone Digital Signal Processor (DSP) are compared with those obtained from the OpenMP implementation provided by Texas Instruments. Results show latency improvements of up to 26% for multicore signal processing systems.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), UBL, Texas Instruments, University of Maryland

Contributors: Heulot, J., Pelcat, M., Nezan, J. F., Oliva, Y., Aridhi, S., Bhattacharyya, S. S.

Number of pages: 5

Pages: 25-29

Publication date: 5 Feb 2014

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Title of host publication: 2014 IEEE Global Conference on Signal and Information Processing, GlobalSIP 2014

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 7032071

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ASJC Scopus subject areas: Signal Processing, Information Systems

DOIs:

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<http://www.scopus.com/inward/record.url?scp=84974558043&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84974558043

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Data flow algorithms for processors with vector extensions: Handling actors with internal state

Full use of the parallel computation capabilities of present and expected CPUs and GPUs require use of vector extensions. Yet many actors in data flow systems for digital signal processing have internal state (or, equivalently, an edge that loops from the actor back to itself) that impose serial dependencies between actor invocations that make vectorizing across actor invocations impossible. Ideally, issues of inter-thread coordination required by serial data dependencies should be handled by code written by parallel programming experts that is separate from code specifying signal processing operations. The purpose of this paper is to present one approach for so doing in the case of actors that maintain state. We propose a methodology for using the parallel scan (also known as prefix sum) pattern to create

algorithms for multiple simultaneous invocations of such an actor that results in vectorizable code. Two examples of applying this methodology are given: (1) infinite impulse response filters and (2) finite state machines. The correctness and performance of the resulting IIR filters are studied.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Keysight Technologies, University of Maryland

Contributors: Barford, L., Bhattacharyya, S. S., Liu, Y.

Number of pages: 5

Pages: 20-24

Publication date: 5 Feb 2014

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ASJC Scopus subject areas: Signal Processing, Information Systems

Keywords: Data flow computing, Digital signal processing, Parallel algorithms, Vector processors

DOIs:

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<http://www.scopus.com/inward/record.url?scp=84983120171&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84983120171

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Dynamic, data-driven spectrum management in cognitive small cell networks

Recently, the deployment of small cells is considered as an effective solution to enhance the capacity in existing cellular networks. However, massive deployment of small cells also incurs severe interference and increased energy consumption, which degrades the energy efficiency of the system. In this paper, we analyze the energy efficiency in cognitive small cell network, and propose a traffic-aware distributed sensing and access scheme for cognitive small cells base stations (SBSs). The proposed scheme adopts the concept of dynamic data driven applications systems (DDDAS). In the DDDAS paradigm, a model of the underlying design space is managed dynamically, updated periodically based on measurements of data, and used to drive measurement functions and adaptation of system configurations. Through careful integration of DDDAS-based design principles, SBSs have the ability to configure their sensing and access parameters according to the traffic patterns that are actually encountered. Simulation results show that our proposed DDDAS-based scheme can achieve significantly higher energy efficiency compared to conventional spectrum sharing schemes in cognitive small cell networks.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), National Chiao-Tung University, Department of Electrical and Computer Engineering, University of Maryland

Contributors: Lee, C. S., Chen, W. C., Bhattacharyya, S. S., Lee, T. S.

Publication date: 23 Jan 2014

#### Host publication information

Title of host publication: 2014, 8th International Conference on Signal Processing and Communication Systems, ICSPCS 2014 - Proceedings

Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 7021121

ISBN (Electronic): 9781479952557

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing, Electrical and Electronic Engineering

Keywords: Cognitive radio, DDDAS, dynamic spectrum access, energy efficiency, small cell, utility

DOIs:

10.1109/ICSPCS.2014.7021121

URLs:

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Source: Scopus

Source ID: 84946686949

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **The lord of the sense: A privacy preserving reputation system for participatory sensing applications**

Electronic devices we use on a daily basis collect sensitive information without preserving user's privacy. In this paper, we propose the lord of the sense (LotS), a privacy preserving reputation system for participatory sensing applications. Our system maintains the privacy and anonymity of information with the use of cryptographic techniques and combines voting approaches to support users' reputation. Furthermore, LotS maintains accountability by tracing back a misbehaving user while maintaining k-anonymity. A detailed security analysis is presented with the current advantages and disadvantages of our system.

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Security Lab, SICS, City University London  
Contributors: Michalás, A., Komninos, N.  
Publication date: 1 Jan 2014

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Title of host publication: 2014 IEEE Symposium on Computers and Communications, ISCC 2014 - Proceedings  
Publisher: Institute of Electrical and Electronics Engineers Inc.  
Article number: 6912480  
ISBN (Electronic): 9781479942787  
ASJC Scopus subject areas: Software, Signal Processing, Mathematics(all), Computer Science Applications, Computer Networks and Communications  
Keywords: Anonymity, Distributed Sensing, Participatory Sensing, Privacy, Reputation Systems, Security, Urban Sensing  
DOIs:  
10.1109/ISCC.2014.6912480  
Source: Scopus  
Source ID: 84908199099  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **On application of rational Discrete Short Time Fourier Transform in epileptic seizure classification**

This work deals with an adaptive and localized time-frequency representation of time-series signals based on rational functions. The proposed rational Discrete Short Time Fourier Transform (DSTFT) is used for extracting discriminative features in EEG data. We take the advantages of bagging ensemble learning and Alternating Decision Tree (ADTree) classifier to detect the seizure segments in presence of seizure-free segments. The effectiveness of different rational systems is compared with the classical Short Time Fourier Transform (STFT). The comparative study demonstrates that Malmquist-Takenaka rational system outperforms STFT while it can provide a tunable time-frequency representation of the EEG signals and less Mean Square Error (MSE) in the inverse transform. © 2014 IEEE.

#### **General information**

Publication status: Published  
MoE publication type: A4 Article in a conference publication  
Organisations: Department of Signal Processing, Research group: Video, Tampere University of Technology, Research Community on Data-to-Decision (D2D), Eötvös Loránd University  
Contributors: Kovács, P., Samiee, K., Gabbouj, M.  
Number of pages: 5  
Pages: 5839-5843  
Publication date: 2014

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Publisher: IEEE  
Article number: 6854723  
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Publisher: IEEE  
ISSN (Print): 1520-6149  
ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering  
Keywords: EEG time series, Malmquist-Takenaka system, rational functions, seizure classification  
DOIs:

10.1109/ICASSP.2014.6854723

URLs:

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#### **Bibliographical note**

Contribution: organisation=sgn,FACT1=1<br/>Portfolio EDEND: 2014-06-26

Source: researchoutputwizard

Source ID: 800

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **An Unsupervised Audio Segmentation Method Using Bayesian Information Criterion**

Audio segmentation is a well-known problem which can be considered from various angles. In the context of this paper, audio segmentation problem is to extract small 'homogeneous' pieces of audio in which the content does not change in terms of the present audio events. The proposed method is compared with the well-known segmentation method; Bayesian Information Criterion (BIC) based Divide-and-Conquer, in terms of average segment duration and computational complexity. © 2014 IEEE.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Video

Contributors: Ozan, E. C., Tankiz, S., Acar, B. O., Ciloglu, T.

Number of pages: 4

Pages: 640-643

Publication date: 2014

#### **Host publication information**

Title of host publication: 6th International Symposium on Communications, Control & Signal Processing, ISCCSP, 21-23.5.2014, Athens, Greece

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Publisher: IEEE

ISBN (Print): 978-1-4799-2890-3

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

Keywords: Audio Segmentation, Bayesian Information Criterion, Energy Based Segmentation

DOIs:

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#### **Bibliographical note**

Contribution: organisation=sgn,FACT1=1<br/>Portfolio EDEND: 2014-08-30<br/>Publisher name: IEEE

Source: researchoutputwizard

Source ID: 1203

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### **Minimum Variance Extreme Learning Machine for human action recognition**

In this paper we propose an algorithm for Single-hidden Layer Feedforward Neural networks training. Based on the observation that the learning process of such networks can be considered to be a non-linear mapping of the training data to a high-dimensional feature space, followed by a data projection process to a low-dimensional space where classification is performed by a linear classifier, we extend the Extreme Learning Machine (ELM) algorithm in order to exploit the training data dispersion in its optimization process. The proposed Minimum Variance Extreme Learning Machine classifier is evaluated in human action recognition, where we compare its performance with that of other ELM-based classifiers, as well as the kernel Support Vector Machine classifier.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

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ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: Classification, Extreme Learning Machine, Human Action Recognition, Single-hidden Layer Feedforward Neural networks

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Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Impact of received signal on self-interference channel estimation and achievable rates in in-band full-duplex transceivers

In this paper we analyze the effect of the calibration period, or lack of, on self-interference channel estimation in the digital domain of in-band full-duplex radio transceivers. In particular, we consider a scenario where the channel estimation must be performed without a separate calibration period, which means that the received signal of interest will act as an additional noise source from the estimation perspective. We will explicitly analyze its effect, and quantify the increase in the parameter estimation variance, or sample size, if similar accuracy for the self-interference channel estimate is to be achieved as with a separate calibration period. In addition, we will analyze how the calibration period, or its absence, affects the overall achievable rates. Full waveform simulations are then used to determine the validity of the obtained results, as well as to provide numerical results regarding the achievable rates. It is shown that, even though a substantial increase in the parameter sample size is required if there is no calibration period, the achievable rates are still comparable for the two scenarios.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)

Contributors: Korpi, D., Anttila, L., Valkama, M.

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ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

DOIs:

10.1109/ACSSC.2014.7094599

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Programmable lowpower implementation of the HEVC Adaptive Loop Filter

The Adaptive Loop Filter (ALF) is a subjective and objective image quality improving filter in the High Efficiency Video Coding standard (HEVC). The ALF has shown to be computationally complex and its complexity has been reduced during the HEVC development process. In the HEVC TestModel HM-7.0 ALF is a  $9 \times 7$  cross +  $3 \times 3$  square shaped filter. This paper presents a programmable application specific instruction processor for the ALF. The proposed processor processes  $1920 \times 1080$ p luminance frames at 30 frames per second, when operated at a clock frequency of 311MHz. Low power consumption and a low gate count make the proposed processor suitable for embedded devices. The processor program code is written in pure C-language, which allows versatile use of the circuit and updates to the filter functionality without modifying the processor design. To the authors' best knowledge this is the first programmable solution for ALF on embedded devices.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Univ of Oulu, Dept. of Computer Science and Engineering

Contributors: Hautala, I., Boutellier, J., Hannuksela, J.

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ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: Adaptive filters, Coprocessors, Video signal processing

DOIs:

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Source: Scopus

Source ID: 84890508061

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Configurable, resource-optimized FFT architecture for OFDM communication

In this paper, we present a designer-configurable, resource efficient FPGA architecture for OFDM system implementation. Our design achieves a significant improvement in resource efficiency for a given data rate. This efficiency improvement is achieved through careful analysis of how FFT computation is performed within the context of OFDM systems, and streamlining memory management and control logic based on this analysis. In particular, our OFDM-targeted FFT design eliminates redundant buffer memory, and simplifies control logic to save FPGA resources. We have synthesized and tested our design using the Xilinx ISE 13.4 synthesis tool, and compared the results with the Xilinx FFT v7.1, which is a widely used commercial FPGA IP core. We have demonstrated that our design provides at least 8.8% enhancement in terms of resource efficiency compared to Xilinx FFT v7.1 when it is embedded within the same OFDM configuration.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Agilent Technologies, Department of Electrical and Computer Engineering

Contributors: Cho, I., Shen, C. C., Tachwali, Y., Hsu, C. J., Bhattacharyya, S. S.

Number of pages: 5

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ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: FFT, FPGA, OFDM, Resource

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Source: Scopus

Source ID: 84890522532

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### On the effect of network structure and synaptic mechanisms on sustained bursting activity

The sustained activity in recurrent networks has been under wide computational examination in studies concerning, e.g., working memory and epilepsy. Synaptic and cellular mechanisms for sustained activity have been reviewed in [1], and the optimal structural features for sustained activity have been sought for in [2]. In this work, we analyze the effect of network structure and synaptic mechanisms on the sustained high-frequency network-wide activity, i.e., sustained network bursts. In more detail, we assess the degree to which the neuronal activity can be maintained by changing fine details of network structure, given a certain set of synaptic mechanisms (e.g., short-term plasticity).

The neurons in our study are modeled as point-neurons that are activated by noisy fluctuations of the membrane potential. Given strong enough recurrent excitatory connections, the spontaneous firing extends to a network-wide sustained activity. Experimental *in vitro* data (e.g., [3]) show that this emergent activity dies out and restarts spontaneously in dissociated cultures. Several mechanisms have been suggested for ceasing the sustained activity, namely, the delayed

activation of the inhibitory population, depletion of glutamatergic resources, and synchronization of the excitatory population [1,4]. The main focus of this work lies on the latter two mechanisms. We employ the integrate-and-fire neuron model with short-term depression [4] for deriving the main results. We also use a more biophysically realistic integrate-and-fire model that combines different synaptic currents, e.g., AMPA and NMDA [5], and a yet more detailed Hodgkin-Huxley-based model [6] to confirm our results. We consider four essentially different classes of network structure: 1) an Erdős-Rényi type of random network 2) a locally connected network, 3) a random network with high occurrence of directed loops of length 6, and 4) a random network with high number of triples of nodes constituting a feed-forward loop. The in-degree distribution of all networks is kept fixed in order to ensure that the networks are comparable.

Our results reveal links between the network excitability and the network structure. In purely excitatory networks with short-term depression, the amount of activity is increased with the synaptic strength, first from spontaneous tonic firing to spontaneous network-wide bursting activity and finally to long or ceaseless bursts. We show that the range of values of synaptic strength for observing one of these three modes depends on the choice of network structure. The networks with a high number of feed-forward loops show an increased ability to cease the burst in the regime of high synaptic strength, whereas the networks with a high number of 6-loops require lower synaptic strength in order to express ceaseless bursting activity. We calculate the parameter ranges of the named three modes of activity for several variations of synaptic currents. We also study the effect of an inhibitory subpopulation on the three modes. The results are discussed in comparison to "superbursts" that can be observed in dissociated cultures [7]. Our results could help in identifying structures that promote sustained bursting activity and further the understanding of contribution of different synaptic mechanisms.

#### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Faculty of Biomedical Sciences and Engineering

Contributors: Mäki-Marttunen, T. M., Acimovic, J., Ruohonen, K. P., Linne, M.

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Editors: Cymbalyuk, G., Prinz, A.

ASJC Scopus subject areas: Neuroscience (miscellaneous), Signal Processing

Keywords: Computational neuroscience, Neuronal networks, Neuronal network activity, Hodgkin-Huxley model neuron, synapses, spontaneous activity, integrate-and-fire model neuron, structure-function relation

URLs:

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Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Rate-distortion based reversible watermarking for JPEG images with quality factors selection

The improved reversible data hiding scheme which is a part of JPEG coding process is introduced. Generally, one of the common constraints imposed on digital watermarking in frequency domain is a small payload that can be embedded without causing high degradation of a JPEG stego image. Moreover, even at small hidden payload the stego image file size will increase to some extent. In no existing data hiding technique compliant with JPEG there is a possibility to define in advance the file size of the watermarked image. Therefore, in this paper we propose to use a rate-distortion theory that minimizes coding distortion subject to a coding rate constraint. An iterative algorithm based on a Lagrangian formulation is applied to obtain a vector of quality factors for each of the  $8 \times 8$  blocks that scale the JPEG standard quantization table. The experimental results show the advantage of the proposed improved watermarking scheme in terms of data payload versus quality and file size compared with the state-of-the-art data hiding schemes, and, furthermore, clarify the improvements of its optimized counterpart. © 2013 University Paris 13.

#### General information

Publication status: Published

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Organisations: Tampere University of Technology, Department of Signal Processing, Research Community on Data-to-Decision (D2D), Signal Processing Research Community (SPRC)

Contributors: Efimushkina, T., Egiazarian, K., Gabbouj, M.

Number of pages: 6

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Name: European Workshop on Visual Information Processing

ASJC Scopus subject areas: Computer Vision and Pattern Recognition, Signal Processing

Keywords: JPEG, Lagrangian relaxation, RateDistortion Optimization, reversible, watermarking

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Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Multi-view human action recognition: A survey

While single-view human action recognition has attracted considerable research study in the last three decades, multi-view action recognition is, still, a less exploited field. This paper provides a comprehensive survey of multi-view human action recognition approaches. The approaches are reviewed following an application-based categorization: methods are categorized based on their ability to operate using a fixed or an arbitrary number of cameras. Finally, benchmark databases frequently used for evaluation of multi-view approaches are briefly described.

#### General information

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Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.

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ASJC Scopus subject areas: Artificial Intelligence, Information Systems, Signal Processing

Keywords: Multi-view action recognition, review, survey

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Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Representative class vector clustering-based discriminant analysis

Clustering-based Discriminant Analysis (CDA) is a well-known technique for supervised feature extraction and dimensionality reduction. CDA determines an optimal discriminant subspace for linear data projection based on the assumptions of normal subclass distributions and subclass representation by using the mean subclass vector. However, in several cases, there might be other subclass representative vectors that could be more discriminative, compared to the mean subclass vectors. In this paper we propose an optimization scheme aiming at determining the optimal subclass representation for CDA-based data projection. The proposed optimization scheme has been evaluated on standard classification problems, as well as on two publicly available human action recognition databases providing enhanced class discrimination, compared to the standard CDA approach.

#### General information

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Organisations: Research Community on Data-to-Decision (D2D), Aristotle University of Thessaloniki, Department of Informatics

Contributors: Iosifidis, A., Tefas, A., Pitas, I.



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ASJC Scopus subject areas: Artificial Intelligence, Information Systems, Signal Processing  
Keywords: class representation, data projection, Discriminant Analysis, feature selection  
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Source ID: 84904490736  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Dynamic action classification based on iterative data selection and Feedforward Neural networks

In this paper we present a dynamic classification scheme involving Single-hidden Layer Feedforward Neural (SLFN) network-based non-linear data mapping and test sample-specific labeled data selection in multiple levels. The number of levels is dynamically determined by the test sample under consideration, while the use of Extreme Learning Machine (ELM) algorithm for SLFN network training leads to fast operation. The proposed dynamic classification scheme has been applied to human action recognition by employing the Bag of Visual Words (BoVW)-based action video representation providing enhanced classification performance compared to the static classification approach.

#### General information

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Contributors: Iosifidis, A., Tefas, A., Pitas, I.  
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ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering  
Keywords: Data selection, Dynamic classification, Extreme Learning Machine, Feedforward Neural network  
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Source ID: 84901331035  
Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Multiplicative update for fast optimization of information retrieval based neighbor embedding

Dimensionality reduction of high-dimensional data for visualization has recently been formalized as an information retrieval task where original neighbors of data points are retrieved from the low-dimensional display, and the visualization is optimized to maximize flexible tradeoffs between precision and recall of the retrieval, avoiding misses and false neighbors. The approach has yielded well-performing visualization methods as well as information retrieval interpretations of earlier neighbor embedding methods. However, most of the methods are based on slow gradient search approaches, whereas fast methods are crucial for example in interactive applications. In this paper we propose a fast multiplicative update rule for visualization optimized for information retrieval, and show in experiments it yields equally good results as the previous state of the art gradient based approach but much faster.

#### General information

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Organisations: Research Community on Data-to-Decision (D2D), Aalto University  
Contributors: Peltonen, J., Lin, Z.  
Publication date: 2013

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ASJC Scopus subject areas: Human-Computer Interaction, Signal Processing

Keywords: dimensionality reduction, information retrieval, multiplicative update, visualization

DOIs:

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Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **An image guided treatment platform for prostate cancer photodynamic therapy**

This study describes a multimodality images based platform to drive photodynamic therapies of prostate cancer using WST 11 TOOKAD Soluble drug. The platform integrates a pre-treatment planning tool based on magnetic resonance imaging and a per-treatment guidance tool based on transrectal ultrasound images. Evaluation of the platform on clinical data showed that prediction of the therapy outcome was possible with an accuracy of 90 %.

#### **General information**

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Organisations: Frontier Photonics, Lille University Hospital - CHRU, Inserm

Contributors: Betrouni, N., Colin, P., Puech, P., Villers, A., Mordon, S.

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Source ID: 84886469344

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **DBComposer: An R package for integrative analysis and management of gene expression microarray data**

DBComposer is an R package with a graphical user interface (GUI) to analyze and integrate human gene expression microarray data. With DBComposer, the data can be easily annotated, preprocessed and analyzed in several ways. DBComposer can also serve as a personal expression microarray database allowing users to store multiple datasets together for later retrieval or data analysis. It takes advantage of many R packages for statistics and visualizations, and provides a flexible framework to implement custom workflows to extend the data analysis capabilities.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Multi-scaled biodata analysis and modelling (MultiBAM)

Contributors: Kong, L., Aho, K. L., Granberg, K., Roos, C., Autio, R.

Number of pages: 2

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DOIs:

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Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **An efficient GPU implementation of an arbitrary resampling polyphase channelizer**

A channelizer is a part of a receiver front-end subsystem, commonly found in various communication systems, that separates different users or channels. A modern channelizer uses advantages of polyphase filter banks to process multiple channels at the same time, allowing down conversion, downsampling, and filtering all at the same time. However, due to limitations imposed by the structure and requirements of channelizers, their usage is limited and poses significant challenges due to inflexibility using conventional implementation techniques, which are intensively hardware-based. However, with advances in graphics processing unit (GPU) technology, we now have the potential to deliver high computational throughput along with the flexibility of software-based implementation. In this paper, we demonstrate how this potential can be exploited by presenting a novel GPU-based channelizer implementation. Our implementation incorporates methods for eliminating complex buffer managements and performing arbitrary resampling on all channels simultaneously. We also introduce the notion of simultaneously processing many channels as a high data rate parallel receiver system using blocks of threads in the GPU. The multi-channel, flexible, high-throughput, and arbitrary resampling characteristics of our GPU-based channelizer make it attractive for a variety of communication receiver applications.

#### **General information**

Publication status: Published

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Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering

Contributors: Kim, S. C., Plishker, W. L., Bhattacharyya, S. S.

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Publication date: 2013

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ASJC Scopus subject areas: Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: Arbitrary resampling, DSP accelerator, Front-end receiver, Polyphase channelizer, Sample rate conversion

URLs:

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Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Design space exploration and implementation of RVC-CAL applications using the TURNUS framework**

While research on the design of heterogeneous concurrent systems has a long and rich history, a unified design methodology and tool support has not emerged so far, and thus the creation of such systems remains a difficult, time-consuming and error-prone process. The absence of principled support for system evaluation and optimization at high abstraction levels makes the quality of the resulting implementation highly dependent on the experience or prejudices of the designer. In this work we present TURNUS, a unified dataflow design space exploration framework for heterogeneous parallel systems. It provides high-level modelling and simulation methods and tools for system level performances estimation and optimization. TURNUS represents the outcome of several years of research in the area of co-design exploration for multimedia stream applications. During the presentation, it will be demonstrated how the initial high-level abstraction of the design facilitates the use of different analysis and optimization heuristics. These guide the designer during validation and optimization stages without requiring low-level implementations of parts of the application. Our framework currently yields exploration and optimization results in terms of algorithmic optimization, rapid performance estimation, application throughput, buffer size dimensioning, and power optimization.

#### **General information**

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MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), CRPP, Lund University, Dept. of Computer Science and Engineering, Univ of Oulu

Contributors: Casale-Brunet, S., Bezati, E., Alberti, C., Roquier, G., Mattavelli, M., Janneck, J. W., Boutellier, J.  
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ASJC Scopus subject areas: Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: Co-exploration, Dataflow, Design space

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Source ID: 84892650917

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### High-performance programs by source-level merging of RVC-CAL dataflow actors

RVC-CAL is a dataflow language that has acquired an ecosystem of sophisticated design tools. Previous works have shown that RVC-CAL-based applications can automatically be deployed to multiprocessor platforms, as well as hardware descriptions with high efficiency. However, as RVC-CAL is a concurrent language, code generation for a single processor core requires careful application analysis and scheduling. Although much work has been done in this area, to this date no publication has reported that programs generated from RVC-CAL could rival handwritten programs on single-core processors. This paper proposes performance optimization of RVCCAL applications by actor merging at source code level. The proposed methodology is demonstrated with an IEEE 802.15.4 (ZigBee) transmitter case study. The transmitter baseband software, previously written in C, is rewritten in RVC-CAL and optimized with the proposed methodology. Experiments show that on a VLIW-flavored processor the RVC-CAL-based program achieves the performance of manually written software.

#### General information

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Organisations: Signal Processing Research Community (SPRC), Dept. of Computer Science and Engineering, Univ of Oulu, Abo Akad Univ, Abo Akademi University, Dept Phys

Contributors: Boutellier, J., Ghazi, A., Silvén, O., Ersfolk, J.

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Keywords: Dataflow computing, Design automation, Signal processing

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Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### Parameterized core functional dataflow graphs and their application to design and implementation of wireless communication systems

Due to the increased complexity of dynamics in modern DSP applications, dataflow-based design methodologies require significant enhancements in modeling and scheduling techniques to provide for efficient and flexible handling of dynamic behavior. In this paper, we address this problem through a new framework that is based on integrating two complementary modeling techniques, core functional dataflow (CFDF) and parameterized synchronous dataflow (PSDF). We apply, in a systematically integrated way, the structured mode-based dynamic dataflow modeling capability of CFDF together with the features of PSDF for dynamic parameter reconfiguration and quasi-static scheduling. We refer to this integrated methodology for mode - and dynamic-parameter - based modeling and scheduling as core functional parameterized synchronous dataflow (CF-PSDF). Through a wireless communication case study involving MIMO detection, we

demonstrate the utility of design and implementation using CF-PSDF graphs. Experimental results on this case study demonstrate the efficiency and flexibility of our proposed new CF-PSDF based design methodology.

#### General information

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Organisations: Signal Processing Research Community (SPRC), University of Maryland

Contributors: Wang, L. H., Shen, C. C., Bhattacharyya, S. S.

Number of pages: 6

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Publication date: 2013

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Keywords: Dataflow graph, Dynamic scheduling, MIMO detector, Parameterized modeling

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Source ID: 84896476923

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

#### A system-level design approach for dynamic resource coordination and energy optimization in sensor network platforms

Strict run-time and resource constraints in wireless sensor networks (WSNs) introduce complex design problems that need to be addressed systematically. Recent processor platforms for WSNs have groups of peripheral devices that are used for data sensing and processing. Hardware interrupts are commonly used as an efficient method for handling data acquisition from such peripherals. Dynamic control for multiple interrupts and efficient handling of power consumption on embedded processors are important issues when implementing dynamic, data-driven signal processing applications, where the structure of processing subsystems may need to be adapted at run-time based characteristics of input data and associated operating conditions. To address these issues, we introduce a dataflow-based design approach based on integrating interrupt-based signal acquisition in the context of parameterized synchronous dataflow (PSDF) modeling. This application of PSDF provides a useful foundation for structured development of power- and energy-efficient wireless sensor network systems for dynamic, data-driven applications systems (DDDAS), including DDDAS that employ intensive acquisition and processing of signals from heterogeneous sensors. To demonstrate our proposed new signal-processing-oriented, dataflow-based design approach - which we refer to as DDPSDF (data-driven PSDF) - we have implemented an embedded speech recognition system using the proposed DDPSDF techniques. We demonstrate that by applying our DDPSDF approach, energy- and resource-efficient embedded software can be derived systematically from high level models of DDDAS functional structure.

#### General information

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MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Laboratory for Physical Sciences, Department of Electrical and Computer Engineering

Contributors: Cho, I., Sudusinghe, K., Shen, C. C., McGee, J., Bhattacharyya, S.

Number of pages: 6

Pages: 1436-1441

Publication date: 2013

#### Host publication information

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Publisher: IEEE COMPUTER SOCIETY PRESS

Article number: 6810533

ISBN (Print): 9781479923908

ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

Keywords: Dataflow graphs, DDDAS, Digital signal processing, Parameterized dataflow, Wireless sensor networks

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URLs:

<http://www.scopus.com/inward/record.url?scp=84901254904&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84901254904

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Programmable implementation of zero-crossing demodulator on an application specific processor**

The zero-intermediate frequency zero-crossing demodulator (ZIFZCD) is extensively used for demodulating continuous phase frequency shift keying (CPFSK) signals in low power and low cost devices. ZIFZCD has previously been implemented as hardwired circuits. Many variations have been suggested to the ZIFZCD algorithm for different modulation methods and channel conditions. To support all these variants, a programmable processor based implementation of the ZIFZCD is needed. This paper describes a programmable software implementation of ZIFZCD on an application specific processor (ASP). The ASP is based on transport triggered architecture (TTA) and provides an ideal low power platform for ZIFZCD implementation due to its simplicity. The designed processor operates at a maximum clock frequency of 250 MHz and has gate count of 134 kGE for a 32-bit TTA processor and 76 kGE for a 16-bit processor. The demodulator has been developed as a part of an open source radio implementation for wireless sensor nodes.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Dept. of Computer Science and Engineering, Univ of Oulu

Contributors: Ghazi, A., Boutellier, J., Hannuksela, J., Shahabuddin, S., Silvén, O.

Number of pages: 6

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Publication date: 2013

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Publisher: Institute of Electrical and Electronics Engineers Inc.

Article number: 6674510

ISBN (Print): 9781467362382

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics, Hardware and Architecture

Keywords: Demodulation, Signal Processing, Software radio

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Source: Scopus

Source ID: 84896460964

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Efficient optimization for data visualization as an information retrieval task**

Visualization of multivariate data sets is often done by mapping data onto a low-dimensional display with nonlinear dimensionality reduction (NLDR) methods. Many NLDR methods are designed for tasks like manifold learning rather than low-dimensional visualization, and can perform poorly in visualization. We have introduced a formalism where NLDR for visualization is treated as an information retrieval task, and a novel NLDR method called the Neighbor Retrieval Visualizer (NeRV) which outperforms previous methods. The remaining concern is that NeRV has quadratic computational complexity with respect to the number of data. We introduce an efficient learning algorithm for NeRV where relationships between data are approximated through mixture modeling, yielding efficient computation with near-linear computational complexity with respect to the number of data. The method inherits the information retrieval interpretation from the original NeRV, it is much faster to optimize as the number of data grows, and it maintains good visualization performance.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Research Community on Data-to-Decision (D2D), Aalto University

Contributors: Peltonen, J., Georgatzis, K.

Publication date: 2012

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Article number: 6349797

ISBN (Print): 9781467310260

ASJC Scopus subject areas: Human-Computer Interaction, Signal Processing

Keywords: dimensionality reduction, efficient computation, mixture modeling, neighbor retrieval, Visualization

DOIs:

10.1109/MLSP.2012.6349797

URLs:

<http://www.scopus.com/inward/record.url?scp=84870701014&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84870701014

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Multidimensional dataflow graph modeling and mapping for efficient GPU implementation**

Multidimensional synchronous dataflow (MDSDF) provides an effective model of computation for a variety of multidimensional DSP systems that have static dataflow structures. In this paper, we develop new methods for optimized implementation of MDSDF graphs on embedded platforms that employ multiple levels of parallelism to enhance performance at different levels of granularity. Our approach allows designers to systematically represent and transform multi-level parallelism specifications from a common, MDSDF-based application level model. We demonstrate our methods with a case study of image histogram implementation on a graphics processing unit (GPU). Experimental results from this study show that our approach can be used to derive fast GPU implementations, and enhance trade-off analysis during design space exploration.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Air Force Research Laboratory Information Directorate, University of Missouri-Columbia, Department of Electrical and Computer Engineering

Contributors: Wang, L. H., Shen, C. C., Seetharaman, G., Palaniappan, K., Bhattacharyya, S. S.

Number of pages: 6

Pages: 300-305

Publication date: 2012

#### **Host publication information**

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Article number: 6363272

ISBN (Print): 9780769548562

ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics, Hardware and Architecture

Keywords: Dataflow graph, Graphics processing unit, Integral histogram, Multidimensional synchronous dataflow

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10.1109/SiPS.2012.10

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Source: Scopus

Source ID: 84875330462

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Application-specific instruction processor for extracting local binary patterns**

Local Binary Pattern (LBP) is texture operator used in preprocessing for object detection, tracking, face recognition and fingerprint matching. Many of these applications are performed on embedded devices, which poses limitations on the implementation complexity and power consumption. As LBP features are computed pixelwise, high performance is required for real time extraction of LBP features from high resolution video. This paper presents an application-specific instruction processor for LBP extraction. The compact, yet powerful processor is capable of extracting LBP features from 1280 × 720p (30 fps) video with a reasonable 304 MHz clock rate. With a low power consumption and an area of less than 16k gates the processor is suitable for embedded devices. Experiments present resource and power consumption measured on an FPGA board, along with processor synthesis results. In terms of latency, our processor requires 17.5 × less clock cycles per LBP feature than a workstation implementation and only 2.0 × more than a hardwired ASIC.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Dept. of Computer Science and Engineering, Univ of Oulu

Contributors: Boutellier, J., Lundbom, I., Janhunen, J., Ylimainen, J., Hannuksela, J.

Number of pages: 8

Pages: 82-89

Publication date: 2012

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Article number: 6385363

ISBN (Print): 9782953998726

ASJC Scopus subject areas: Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: Digital signal processors, Feature extraction, Image texture analysis, Video signal processing

URLs:

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Source: Scopus

Source ID: 84872397244

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Systematic integration of flowgraph- and module-level parallelism in implementation of DSP applications on multiprocessor systems-on-chip**

Increasing use of multiprocessor system-on-chip (MPSoC) technology is an important trend in the design and implementation of signal processing systems. However, the design of efficient DSP software for MPSoC platforms involves complex inter-related steps, including data decomposition, memory management, and inter-task and inter-thread synchronization. These design steps are challenging, especially under strict constraints on performance and power consumption, and tight time to market pressures. To facilitate these steps, we have developed a new dataflow based design flow within the targeted dataflow interchange format (TDIF) design tool. Our new MPSoC-oriented design flow, called TDIF-PPG, is geared towards analysis and mapping of embedded DSP applications on MPSoCs. An important feature of TDIF-PPG is its capability to integrate graph level parallelism for DSP system flowgraphs and actor level parallelism for DSP functional modules into the application mapping processing. Here, graph level parallelism is exposed by the dataflow graph application representation in TDIF, and actor level parallelism is modeled by a novel model for multiprocessor dataflow graph implementation that we call the parallel processing group (PPG) model. We demonstrate our approach through actor and subsystem design for software defined radio.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering

Contributors: Zhou, Z., Shen, C. C., Plishker, W., Wu, H. H., Bhattacharyya, S. S.

Number of pages: 7

Pages: 402-408

Publication date: 2012

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Article number: 6491686

ISBN (Print): 9781467321945

ASJC Scopus subject areas: Software, Signal Processing, Computer Science Applications

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<http://www.scopus.com/inward/record.url?scp=84876463174&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 84876463174

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **GPU-based acceleration of symbol timing recovery**

This paper presents a novel implementation of graphics processing unit (GPU) based symbol timing recovery using polyphase interpolators to detect symbol timing error. Symbol timing recovery is a compute intensive procedure that detects and corrects the timing error in a coherent receiver. We provide optimal sample-time timing recovery using a maximum likelihood (ML) estimator to minimize the timing error. This is an iterative and adaptive system that relies on feedback, therefore, we present an accelerated implementation design by using a GPU for timing error detection (TED), enabling fast error detection by exploiting the 2D filter structure found in the polyphase interpolator. We present this hybrid/heterogeneous CPU and GPU architecture by computing a low complexity and low noise matched filter (MF) while simultaneously performing TED. We then compare the performance of the CPU vs. GPU based timing recovery for different interpolation rates to minimize the error and improve the detection by up to a factor of 35. We further improve the process by utilizing GPU optimization and performing block processing to improve the throughput even more, all while maintaining the lowest possible sampling rate.



### General information

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MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering, Rice University

Contributors: Kim, S. C., Plishker, W. L., Bhattacharyya, S. S., Cavallaro, J. R.

Number of pages: 8

Pages: 273-280

Publication date: 2012

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Title of host publication: DASIP 2012 - Proceedings of the 2012 Conference on Design and Architectures for Signal and Image Processing

Article number: 6385393

ISBN (Print): 9782953998726

ASJC Scopus subject areas: Computer Graphics and Computer-Aided Design, Computer Vision and Pattern Recognition, Hardware and Architecture, Signal Processing, Electrical and Electronic Engineering

Keywords: coherent receiver design, DSP accelerator, GPU, symbol timing recovery, synchronization

URLs:

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Source ID: 84872402791

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### NT-SIM: A co-simulator for networked signal processing applications

In networked signal processing systems, network nodes that perform embedded processing on sensory inputs and other data interact across wired or wireless communication networks. In such applications, the processing on individual network nodes can be described in terms of dataflow graphs. However, to analyze the correctness and performance of these applications, designers must understand the interactions across these individual "node-level" dataflow graphs - as they communicate across the network in addition to the characteristics of the individual graphs. In this paper, we develop a new simulation environment, called the NS-2 - TDIF SIMulation environment (NT-SIM) - that provides integrated co-simulation of networked signal processing systems. NT-SIM systematically combines the network analysis capabilities provided by the Network Simulator (ns) with the scheduling capabilities of a dataflow-based framework, thereby providing novel features for more comprehensive simulation of networked signal processing systems. Through a novel integration of tools for network and dataflow graph simulation, our NT-SIM environment allows comprehensive simulation and analysis of networked signal processing systems. We present a case study that concretely demonstrates the utility of NT-SIM in the context of a heterogeneous signal processing system design.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland

Contributors: Won, S., Shen, C. C., Bhattacharyya, S. S.

Number of pages: 5

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Publication date: 2012

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ISBN (Print): 9781467310680

ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

Keywords: co-simulation, dataflow graphs, heterogeneous computing, scheduling

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Source: Scopus

Source ID: 84869756660

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Parameterized scheduling for signal processing systems using topological patterns

In recent work, a graphical modeling construct called "topological patterns" has been shown to enable concise representation and direct analysis of repetitive dataflow graph sub-structures in the context of design methods and tools for digital signal processing systems [1]. In this paper, we present a formal design method for specifying topological patterns and deriving parameterized schedules from such patterns based on a novel schedule model called the scalable schedule tree. The approach represents an important class of parameterized schedule structures in a form that is intuitive

for representation and efficient for code generation. We demonstrate our methods for topological pattern representation, scalable schedule tree derivation, and associated dataflow graph code generation using a case study for image processing.

#### **General information**

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MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering

Contributors: Wu, S., Shen, C. C., Sane, N., Davis, K., Bhattacharyya, S. S.

Number of pages: 4

Pages: 1561-1564

Publication date: 2012

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Article number: 6288190

ISBN (Print): 9781467300469

ASJC Scopus subject areas: Software, Signal Processing, Electrical and Electronic Engineering

Keywords: image registration, scheduling, software tools

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Source: Scopus

Source ID: 84867599709

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Emergence of global and local structural features during development of neuronal networks**

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Faculty of Biomedical Sciences and Engineering

Contributors: Acimovic, J.

Publication date: 6 Jun 2011

#### **Host publication information**

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Place of publication: Tampere

Publisher: TICSP

#### **Publication series**

Name: TICSP Series

Publisher: Tampere International Center for Signal Processing

Volume: 57

ASJC Scopus subject areas: Signal Processing, Cellular and Molecular Neuroscience, Neuroscience (miscellaneous)

Keywords: morphology, connectivity, complex networks, neurite, dendritic structure

URLs:

[https://iris.unimore.it/retrieve/handle/11380/699320/40887/WCSB\\_villanibarbieriserra\\_final\\_TICSP.pdf](https://iris.unimore.it/retrieve/handle/11380/699320/40887/WCSB_villanibarbieriserra_final_TICSP.pdf)

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Effects of structure on spontaneous activity in simulated neuronal networks**

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, BioMediTech, Research group: Computational Neuro Science-CNS, Faculty of Biomedical Sciences and Engineering, Department of Mathematics, Research group: Computational Neuro Science-CNS

Contributors: Mäki-Marttunen, T., Acimovic, J., Ruohonen, K., Linne, M.

Publication date: 11 Apr 2011

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Title of host publication: Proceedings of Mathematical Neuroscience (ICMS 2011), April 11-13, 2011, Edinburgh, Scotland  
ASJC Scopus subject areas: Cellular and Molecular Neuroscience, Neuroscience (miscellaneous), Applied Mathematics, Signal Processing

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Automatic synthesis of TTA processor networks from RVC-CAL dataflow programs

The RVC-CAL dataflow language has recently become standardized through its use as the official language of Reconfigurable Video Coding (RVC), a recent standard by MPEG. The tools developed for RVC-CAL have enabled the transformation of RVC-CAL dataflow programs into C language and VHDL (among others), enabling implementations for instruction processors and HDL synthesis. This paper introduces new tools that enable automatic creation of heterogeneous multiprocessor networks out of RVC-CAL dataflow programs. Each processor in the network performs the functionality of one RVC-CAL actor. The processors are of the Transport Triggered Architecture (TTA) type, for which a complete co-design toolset exists. The existing tools enable customizing the processors according to the requirements of individual dataflow actors. The functionality of the tool chain has been demonstrated by synthesizing an MPEG-4 Simple Profile video decoder to an FPGA. This particular decoder is automatically realized into 21 tiny, heterogeneous processors.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Computer Science and Engineering Laboratory, Univ of Oulu, UBL

Contributors: Boutellier, J., Silvén, O., Raulet, M.

Number of pages: 6

Pages: 25-30

Publication date: 2011

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ASJC Scopus subject areas: Signal Processing

Keywords: data flow computing, design automation, multiprocessor interconnection

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Source: Scopus

Source ID: 84055198564

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### Vectorization and mapping of software defined radio applications on heterogeneous multi-processor platforms

A variety of multiprocessor architectures have proliferated even for off-the-shelf computing platforms. To improve performance and productivity for common heterogeneous systems, we have developed a workflow to generate efficient solutions. By starting with a formal description of an application and the mapping problem we are able to generate a range of designs that efficiently trade-off latency and throughput. In this approach, efficient utilization of SIMD cores is achieved by applying extensive block processing in conjunction with efficient mapping and scheduling. We demonstrate our approach through an integration into the GNU Radio environment for software defined radio system design.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Maryland, Department of Electrical and Computer Engineering, Virginia Tech, Laboratory for Telecommunications Sciences

Contributors: Zaki, G. F., Plishker, W., Bhattacharyya, S. S., Clancy, C., Kuykendall, J.

Number of pages: 6

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Keywords: Design Methodology, Graphic Processor Unit, Multiprocessor Scheduling, Software Defined Radio

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Source: Scopus

Source ID: 84055198557

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Blind estimation of mixed noise parameters in images using robust regression curve fitting**

Methods for blind estimation of signal dependent noise parameters from scatter-plots by polynomial regression are considered. Some new modifications as well as known ones are discussed and their performance is compared for test images with simulated signal dependent noise. Recommendations on method application and parameter setting are given.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Signal Processing Research Community (SPRC), Kharkiv National Aerospace University, Institute for Signal Processing, Universite de Rennes

Contributors: Zabrodina, V., Abramov, S., Lukin, V., Astola, J., Vozel, B., Chehdi, K.

Number of pages: 5

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Publication date: 2011

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ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

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Source: Scopus

Source ID: 84863770803

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Model-based precision analysis and optimization for digital signal processors**

Embedded signal processing has witnessed explosive growth in recent years in both scientific and consumer applications, driving the need for complex, high-performance signal processing systems that are largely application driven. In order to efficiently implement these systems on programmable platforms such as digital signal processors (DSPs), it is important to analyze and optimize the application design from early stages of the design process. A key performance concern for designers is choosing the data format. In this work, we propose a systematic and efficient design flow involving model-based design to analyze application data sets and precision requirements. We demonstrate this design flow with an exploration study into the required precision for eigenvalue decomposition (EVD) using the Jacobi algorithm. We demonstrate that with a high degree of structured analysis and automation, we are able to analyze the data set to derive an efficient data format, and optimize important parts of the algorithm with respect to precision.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Texas Instruments, University of Maryland

Contributors: Kedilaya, S., Plishker, W., Purkovic, A., Johnson, B., Bhattacharyya, S. S.

Number of pages: 5

Pages: 506-510

Publication date: 2011

#### **Host publication information**

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ASJC Scopus subject areas: Signal Processing, Electrical and Electronic Engineering

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Source: Scopus

Source ID: 84863733072

Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

### **Modeling and optimization of dynamic signal processing in resource-aware sensor networks**

Sensor node processing in resource-aware sensor networks is often critically dependent on dynamic signal processing functionality - i.e., signal processing functionality in which computational structure must be dynamically assessed and adapted based on time-varying environmental conditions, operating constraints or application requirements. In dynamic signal processing systems, it is important to provide flexibility for run-time adaptation of application behavior and execution characteristics, but in the domain of resource-aware sensor networks, such flexibility cannot come with significant costs in terms of power consumption overhead or reduced predictability. In this paper, we review a variety of complementary models of computation that are being developed as part of the dataflow interchange format (DIF) project to facilitate efficient and reliable implementation of dynamic signal processing systems. We demonstrate these methods in the context of resource-aware sensor networks.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), Department of Electrical and Computer Engineering, University of Maryland

Contributors: Bhattacharyya, S. S., Plishker, W., Sane, N., Shen, C. C., Wu, H. H.

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Publication date: 2011

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ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing

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Source: Scopus

Source ID: 80053983055

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Scheduling of CAL actor networks based on dynamic code analysis**

CAL is a dataflow oriented language for writing high-level specifications of signal processing applications. The language has recently been standardized and selected for the new MPEG Reconfigurable Video Coding standard.

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Signal Processing Research Community (SPRC), University of Oulu, Univ of Oulu, UBL

Contributors: Boutellier, J., Silven, O., Raulet, M.

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ASJC Scopus subject areas: Signal Processing, Software, Electrical and Electronic Engineering

Keywords: data flow computing, Processor scheduling, video coding

DOIs:

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Source: Scopus

Source ID: 80051648157

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **On delay distribution in IEEE 802.11 wireless networks**

IEEE 802.11 wireless networks have received much attention over the past number of years. Still certain aspects of behavior of wireless networks have not been studied well enough. For example, understanding MAC layer packet delay distribution remains challenging yet. However, obtaining such distribution is highly beneficial for modeling QoS provided by wireless networks. This paper proposes a way of obtaining MAC delay distribution in case of single-hop networks. The proposed way is based on theory of terminating renewal processes and delivers approximation of good precision.

#### **General information**

Publication status: Published

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Organisations: Wireless Communications and Positioning (WICO), Waterford Institute of Technology,

Telecommunications Software and Systems Group (TSSG)

Contributors: Ivanov, S., Botvich, D., Balasubramaniam, S.

Number of pages: 3

Pages: 254-256

Publication date: 2011

#### **Host publication information**

Title of host publication: 16th IEEE Symposium on Computers and Communications, ISCC'11

Article number: 5983849

ISBN (Print): 9781457706783

ASJC Scopus subject areas: Software, Signal Processing, Mathematics(all), Computer Science Applications, Computer Networks and Communications

Keywords: delay distribution, IEEE 802.11, MAC layer, modeling

DOIs:

10.1109/ISCC.2011.5983849

URLs:

<http://www.scopus.com/inward/record.url?scp=80052734083&partnerID=8YFLogxK> (Link to publication in Scopus)

Source: Scopus

Source ID: 80052734083

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Computational modeling of growth in cortical cultures using the NETMORPH simulation tool**

Spontaneously developing cortical cultures represent a convenient experimental model system to study the growth and maturation of neurons and neuronal networks. Different microscopical techniques in combination with cell staining provide a possibility to monitor the morphological changes of neurons as well as synaptogenesis. We study the growth in cortical cultures through mathematical models and numerical simulations, using a recently published simulator NETMORPH (Koene et al. 2009). The construction of the simulator is based on the extensive studies of neuron growth in vitro and the statistical description of relevant phenomena, such as neurite elongation rate, elongation direction, and neurite branching (van Pelt & Uylings 2005). The precise dynamics of biophysical processes involved in growth is not included, but only the statistical description of morphology. The obtained model thus has moderate complexity, with relatively low number of model parameters. Single neuron descriptions are incorporated into the computational model of neuronal cultures, consisting of around 10000 neurons, in (Koene et al. 2009). In our study we focus on the first two weeks in vitro. At the beginning of simulations neurons are disconnected, and the first synapses are formed until the end of first week in vitro. The number of synapses per cell progressively increases until the end of second week in vitro. The range of relevant model parameters is first constrained in accordance with the experimental evidences. This parameter space is systematically sampled and the statistics describing the networks of neurons at the end of the first and second week in vitro is obtained through simulations. The relevant network parameters are adopted from graph theory. Each neuron soma represents a node in the graph, and a synapse formed between a dendrite of one and the axon of another neuron represents an edge in the graph. The number of synapses between two neurons can be described as a weight of the corresponding edge. The graph measures, including in- and out-degree distributions and statistics of motifs (Milo et al. 2002), are then extracted. Our preliminary study demonstrates how precisely these parameters describe the network structure during growth. Here, we are further analyzing how the single cell growth parameters, for example the probability of branching, reflect on the network structure. Finally, the obtained results are compared to the experimental evidence describing the distribution of potential synapses developed in cortical cultures (Ichikawa et al. 1993).

#### **General information**

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Department of Signal Processing, Research group: Algebraic and Algorithmic Methods in Signal Processing AAMSP, Research group: Computational Systems Biology

Contributors: Acimovic, J., Mäki-Marttunen, T., Linne, M.

Pages: 2 p

Publication date: 2010

### Host publication information

Title of host publication: Neuroscience 2010, 40th Annual Meeting, San Diego, USA, 13-17 November 2010

ASJC Scopus subject areas: Neuroscience (miscellaneous), Signal Processing

Keywords: computational model, morphology, neurite structure, connectivity, structured connectivity

URLs:

<http://www.abstractsonline.com/Plan/ViewAbstract.aspx?mID=2554&sKey=f3ce95ee-02ad-4c1f-8871-c673e6f6e717&cKey=e0908b3a-79fb-45f5-84d2-dcbbba7b8b26&mKey=e5d5c83f-ce2d-4d71-9dd6-fc7231e090fb>

### Bibliographical note

Contribution: organisation=sgn,FACT1=1

Source: researchoutputwizard

Source ID: 7616

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Computational tools for assessing the properties of 2D neural cell cultures

Neurons cultured in vitro provide a particularly promising experimental system for the analysis of properties, such as information coding, transmission, and learning, that are conventionally associated with biological neural networks. In these systems, isolated cells are placed on top of a recording plate (microelectrode array, MEA), where they spontaneously develop a random connectivity structure. Typical cultures consist of several thousands of neurons and the connectivity density varies from very low at the beginning of an experimental trial to high in mature cultures. In the absence of external stimuli, a culture exhibits a typical pattern of spontaneous activity, alternating intervals of slow spiking and bursting with the transition intervals of increasing activity. Spontaneous activity recorded in the cultures of rat cortical cells is described in [1, 2] and an explanation of the phenomena is proposed in [3]. The behavior in the presence of external stimuli is also reported in the literature, for example, the adaptation exhibited in the presence of frequent and rare stimuli is assessed experimentally and through a computational model in [4]. The present work is related to the previously reported study [3] in which an image-processing algorithm is used to detect some structural parameters of cell cultures. A typical result from this study is illustrated in Figure 1. The original image of cultured cells on top of recording plate is shown in panel A, one of its segments in B, and the result of the applied algorithm in C. The blue pattern on panel C corresponds to cells. This approach, in general, enables automated estimation of parameters like the number of cells, or the average density of connections between the cells. Here, we propose a computational model based on the study in [3]. The neural network model is composed of leaky integrate-and-fire neurons, connected in a recurrent network as shown in panel D. The network is fed with the quantitative information about the structure of the cell cultures. Such model, although approximate, captures well the essential properties of the topologies observed in cultures. The presented model is used to reproduce and analyze network behavior observed in the absence of external stimuli. The structural parameters are estimated in different phases of development to closely relate them to the observed behavior. The relation between the network topology and behavior is systematically examined throughout this study.

### General information

Publication status: Published

MoE publication type: A4 Article in a conference publication

Organisations: Faculty of Biomedical Sciences and Engineering

Contributors: Acimovic, J., Teppola, H., Selinummi, J. J., Linne, M.

Number of pages: 1

Pages: P170

Publication date: 13 Jul 2009

### Host publication information

Title of host publication: Eighteenth Annual Computational Neuroscience Meeting: CNS\*2009

Volume: 10 (Suppl 1)

Place of publication: Berlin

Publisher: BioMed Central

Editor: Johnson, D.

Article number: P170

ASJC Scopus subject areas: Neuroscience (miscellaneous), Signal Processing

Keywords: external stimulus, spontaneous activity, connectivity structure, microelectrode array, recurrent network

URLs:

<https://bmcneurosci.biomedcentral.com/articles/10.1186/1471-2202-10-S1-P170>

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### Guest Editorial Special Issue on Multimedia Big Data in Internet of Things

#### General information

Publication status: Published

MoE publication type: B1 Article in a scientific magazine

Organisations: Signal Processing, Research group: Multimedia Research Group - MRG, Beijing University of Posts and Telecommunications, University of Technology Sydney, IBM Research  
Contributors: Ma, H., Yu, S., Gabbouj, M., Mueller, P.  
Number of pages: 3  
Pages: 3405-3407  
Publication date: Oct 2018  
Peer-reviewed: No

#### **Publication information**

Journal: IEEE Internet of Things Journal

Volume: 5

Issue number: 5

Article number: 8534720

ISSN (Print): 2327-4662

Ratings:

Scopus rating (2018): CiteScore 9.4 SJR 1.396 SNIP 4.174

Original language: English

ASJC Scopus subject areas: Signal Processing, Information Systems, Hardware and Architecture, Computer Science Applications, Computer Networks and Communications

DOIs:

10.1109/JIOT.2018.2875580

Source: Scopus

Source ID: 85056768996

Research output: Contribution to journal › Editorial › Scientific

#### **Guest Editorial: Implementation Issues in System-on-Chip**

##### **General information**

Publication status: Published

MoE publication type: B1 Article in a scientific magazine

Organisations: Electronics and Communications Engineering, Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing, Tallinn University of Technology

Contributors: Ellervee, P., Nurmi, J.

Number of pages: 2

Pages: 269-270

Publication date: 1 Jun 2017

Peer-reviewed: No

##### **Publication information**

Journal: Journal of Signal Processing Systems

Volume: 87

Issue number: 3

ISSN (Print): 1939-8018

Ratings:

Scopus rating (2017): CiteScore 1.7 SJR 0.216 SNIP 0.632

Original language: English

ASJC Scopus subject areas: Control and Systems Engineering, Theoretical Computer Science, Signal Processing, Information Systems, Modelling and Simulation, Hardware and Architecture

Electronic versions:

Guest Editorial SOC2014\_v1. Embargo ended: 6/04/18

DOIs:

10.1007/s11265-017-1242-x

URLs:

<http://urn.fi/URN:NBN:fi:tty-201802141232>. Embargo ended: 6/04/18

Source: Scopus

Source ID: 85017177298

Research output: Contribution to journal › Editorial › Scientific

#### **Introduction to the Special Section on Sound Scene and Event Analysis**

The papers in this special section are devoted to the growing field of acoustic scene classification and acoustic event recognition. Machine listening systems still have difficulties to reach the ability of human listeners in the analysis of realistic acoustic scenes. If sustained research efforts have been made for decades in speech recognition, speaker identification and to a lesser extent in music information retrieval, the analysis of other types of sounds, such as environmental sounds, is the subject of growing interest from the community and is targeting an ever increasing set of



audio categories. This problem appears to be particularly challenging due to the large variety of potential sound sources in the scene, which may in addition have highly different acoustic characteristics, especially in bioacoustics. Furthermore, in realistic environments, multiple sources are often present simultaneously, and in reverberant conditions.

#### General information

Publication status: Published

MoE publication type: B1 Article in a scientific magazine

Organisations: Signal Processing, University Paris-Saclay, New York University, National Institute of Informatics, University of Toulon

Contributors: Richard, G., Virtanen, T., Bello, J. P., Ono, N., Glotin, H.

Number of pages: 3

Pages: 1169-1171

Publication date: 1 Jun 2017

Peer-reviewed: No

#### Publication information

Journal: IEEE/ACM Transactions on Audio Speech and Language Processing

Volume: 25

Issue number: 6

ISSN (Print): 2329-9290

Ratings:

Scopus rating (2017): CiteScore 4.9 SJR 0.841 SNIP 2.152

Original language: English

ASJC Scopus subject areas: Signal Processing, Media Technology, Instrumentation, Acoustics and Ultrasonics, Linguistics and Language, Speech and Hearing, Electrical and Electronic Engineering

DOIs:

10.1109/TASLP.2017.2699334

Source: Scopus

Source ID: 85028340233

Research output: Contribution to journal > Article > Scientific

#### Guest editorial special issue on the internet of nano things

The six papers in this special section focus on the Internet of nanotechnology things. While researchers are currently investigating these challenges to develop fully functional nano communication systems, a question remains as to whether they can represent an extended communication network that is part of the broader Internet. These papers address new solutions for the Internet of Nano Things. The Internet of Things paradigm has transformed the way we operate our personal and professional lives, it is driving our economy and will continue to enable many new opportunities in broad research areas. As this pervasive and ubiquitous interconnection of our everyday life appliances continues into the future, new types of devices enabled by nano and biotechnology promise to push engineering to previously unexplored application domains, where the exchange of information and access from/to the broader Internet for their monitoring and control are even more essential. The research on nanoscale communication and networks aims to develop systems for interconnecting these novel devices at the nanoscale, i.e., the Internet of Nano Things.

#### General information

Publication status: Published

MoE publication type: B1 Article in a scientific magazine

Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Nano Communication Centre, State University of New York, University of Nebraska - Lincoln

Contributors: Balasubramaniam, S., Jornet, J. M., Pierobon, M., Koucheryavy, Y.

Number of pages: 3

Pages: 1-3

Publication date: 1 Feb 2016

Peer-reviewed: No

#### Publication information

Journal: IEEE Internet of Things Journal

Volume: 3

Issue number: 1

ISSN (Print): 2327-4662

Ratings:

Scopus rating (2016): CiteScore 8 SJR 1.447 SNIP 6.181

Original language: English

ASJC Scopus subject areas: Computer Networks and Communications, Computer Science Applications, Hardware and Architecture, Information Systems, Signal Processing, Information Systems and Management

DOIs:

10.1109/JIOT.2016.2516838

Source: Scopus

Source ID: 84959329564

Research output: Contribution to journal > Article > Scientific

### **Effects of local structure of neuronal networks on spiking activity in silico**

The structure of the neuronal network, including synaptic connectivity, is the basis for information transfer in the network. Various graph-theoretic measures such as degree distribution, mean geodesic path length, clustering coefficient and motif distribution exist for analysing the structure of networks [1], and each of them captures only one perspective of the properties that are crucial regarding the activity in the network. In this work, we vary the local structure of neuronal networks and observe changes in their activity in silico, i.e. in simulations where the activity of single neurons and their interaction is modeled. The local structure is analysed through the occurrence of different motifs, i.e. different patterns of connectivity. The effect of motifs on network dynamics has been widely studied in different types of networks: from the stability point of view in networks with unspecified dynamics [2], in artificial neural networks [3], and from synchronization point of view in spiking neuronal networks [4]. Our work focuses on noise-driven neuronal networks, where the activity can be characterised by spike trains of neurons in the network, and particularly by the bursting behaviour of the network.

To study the local structure of networks we consider the occurrences of three separate connectivity patterns: (1) the bidirectional edges, (2) the loops of three nodes, and (3) the feed-forward motifs of triples of nodes. Networks with one of these three local connectivity patterns promoted are generated – we abbreviate these networks (L1), (L2) and (L3). In addition, different distance-dependent networks are generated, including networks with ring topology (RT) and biologically plausible topology, obtained by the NETMORPH [5] simulator (NM). All networks except for NM have binomially distributed in-degree, as is the case with the random networks (RN) that are widely used in neuronal activity simulations. Small illustrations of these network structures are shown in Figure Figure 1.1. Neuronal activity in these types of networks of size  $N=100$  is simulated using the model presented in [6]. The simulations show a difference in the activity of these networks. Preliminary results indicate, that network bursts occur more frequently in distance dependent networks RT and NM, especially in RT. Accordingly, the overall spiking frequency is high in these networks, but also in L3 networks.

#### **General information**

Publication status: Published

MoE publication type: Not Eligible

Organisations: Department of Signal Processing, Faculty of Biomedical Sciences and Engineering, Research group: Computational Neuro Science-CNS, Department of Mathematics, Research group: Computational Neuro Science-CNS

Contributors: Mäki-Marttunen, T. M., Acimovic, J., Ruohonen, K. P., Linne, M.

Number of pages: 1

Pages: P202

Publication date: 18 Jul 2011

#### **Host publication information**

Title of host publication: Twentieth Annual Computational Neuroscience Meeting: CNS\*2011

Volume: 12 (Suppl 1)

Place of publication: Stockholm

Publisher: BioMed Central

Editors: Fellous, J., Prinz, A.

ASJC Scopus subject areas: Neuroscience (miscellaneous), Cellular and Molecular Neuroscience, Signal Processing

Keywords: spiking neuronal network, structure, complex networks

URLs:

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3240304/>

Research output: Chapter in Book/Report/Conference proceeding > Conference contribution > Scientific > peer-review

### **Influences of digital band-pass filtering on the BCG waveform**

The band pass filter is used to attenuating breathing originated signal from the heart originated BCG signal. The bandwidth of the both signals slightly overlap, hereby the complete attenuation of the breathing is not possible without also altering the heart originated BCG waveforms and the parameters which are obtained from the BCG. In our study we investigated the optimal lower cut-off frequency, and 1.3 Hz was found as the reasonable compromise between the attenuation of the breathing and the altering of the heart originated BCG.

#### **General information**

Publication status: Published

MoE publication type: Not Eligible

Organisations: Department of Signal Processing, Department of Signal Processing, Institute for Signal Processing, Tampere University Hospital

Contributors: Koivuluoma, M., Barna, L., Koivistoinen, T., Kööbi, T., Värri, A.

Number of pages: 6

Pages: 84-89  
Publication date: 13 Nov 2008

#### Host publication information

Title of host publication: BIOSIGNALS 2008 - Proceedings of the 1st International Conference on Bio-inspired Systems and Signal Processing  
ISBN (Print): 9789898111180  
ASJC Scopus subject areas: Signal Processing, Biomedical Engineering, Control and Systems Engineering  
Keywords: Ballistocardiogram, EMFi, ProHeMon  
Source: Scopus  
Source ID: 55649101440  
Research output: Chapter in Book/Report/Conference proceeding › Conference contribution › Scientific › peer-review

#### Data-driven study of synchronous population activity in generic spiking neuronal networks: How much do we capture using the minimal model for the considered phenomena?

##### General information

Publication status: Published  
Organisations: Faculty of Biomedical Sciences and Engineering  
Contributors: Acimovic, J., Teppola, H., Mäki-Marttunen, T. M., Linne, M.  
Number of pages: 1  
Pages: 68-69  
Publication date: 29 Oct 2018  
Peer-reviewed: Yes

##### Publication information

Journal: BMC Neuroscience  
Volume: 19  
Issue number: Suppl 2  
ISSN (Print): 1471-2202  
Ratings:  
Scopus rating (2018): CiteScore 4 SJR 1.017 SNIP 0.831  
Original language: English  
ASJC Scopus subject areas: Neuroscience (miscellaneous), Signal Processing  
Keywords: spiking neuronal network, neuronal activity, spontaneous activity, data-driven computational model, model fitting, short-term synaptic dynamics  
Research output: Contribution to journal › Meeting Abstract › Scientific › peer-review

#### Data-driven study of synchronous population activity in generic spiking neuronal networks: How much do we capture using the minimal model for the considered phenomena?

##### General information

Publication status: Published  
Organisations: Faculty of Biomedical Sciences and Engineering, Research group: Computational Neuro Science-CNS, Research group: Computational Neuro Science-CNS  
Contributors: Acimovic, J., Teppola, H., Mäki-Marttunen, T. M., Linne, M.  
Publication date: 20 Sep 2018  
Peer-reviewed: Unknown  
Event: Paper presented at Brain and Mind Symposium 2018, Helsinki, Finland.  
ASJC Scopus subject areas: Cellular and Molecular Neuroscience, Neuroscience (miscellaneous), Signal Processing  
URLs:  
[https://www.helsinki.fi/sites/default/files/atoms/files/bm\\_sympo\\_posters.pdf](https://www.helsinki.fi/sites/default/files/atoms/files/bm_sympo_posters.pdf)  
Research output: Other conference contribution › Paper, poster or abstract › Scientific

#### Neural networks, cell cultures and some older work on data analysis.

##### General information

Publication status: Published  
Organisations: Faculty of Biomedical Sciences and Engineering  
Contributors: Acimovic, J.  
Publication date: 15 Jun 2009  
Peer-reviewed: Unknown  
Event: Paper presented at Okinawa Computational Neuroscience Course 2009, Japan.  
ASJC Scopus subject areas: Cellular and Molecular Neuroscience, Neuroscience (miscellaneous), Modelling and Simulation, Signal Processing, Human-Computer Interaction

Keywords: computational neuroscience, spiking networks, complex networks, cortical networks, brain-machine interfaces  
Research output: Other conference contribution › Paper, poster or abstract › Scientific