Forty-Eighth Asilomar Conference on Signals, Systems, and Computers

November 2–5, 2014

FINAL PROGRAM & ABSTRACTS

Asilomar Hotel
Conference Grounds

FORTY-EIGHTH
ASILOMAR CONFERENCE ON
SIGNALS, SYSTEMS & COMPUTERS

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IEEE Signal Processing Society

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Welcome from the General Chair

Prof. Roger Woods, Queen's University Belfast, UK

Welcome to the 48th Asilomar Conference on Signals, Systems, and Computers! I have had a long involvement with the Conference since my first publication in 1997 when I was immediately struck by the unique nature of the Asilomar conference environment. The picturesque sand dunes and warm sunshine provide a wonderful backdrop to a conference that allows easy access to, and interaction with key researchers. Understandably, over the years, I have needed little persuasion to attend. There will never be a better opportunity to capture the attention of a key researcher in your area of expertise than at Asilomar!

The technical program was crafted expertly by the Technical Program Chair, Geert Leus, and his team of Technical Area Chairs: Shengli Zhou, Zhengdao Wang, Bhaskar Rao, Michael Rabbat, Zhi Tian, Visa Koivunen, Selin Aviyente, Jorn Janneck, Mohsin Jamali, and Matt McKay. I would like to thank Geert and his team for assembling a high quality program with 437 accepted papers and 163 invited papers. The student paper contest this year has been chaired by Joe Cavallaro and he has selected a total of 11 submissions. The student finalists will present poster presentations to the judges on Sunday afternoon and, of course, everyone is welcome to attend. The awards for the top three papers will be made at the plenary session. A key innovation this year has been to inculcate two major themes, brain machine interface and neural networks, and processing of high dimensional large scale data.

This year's plenary talk will be given by Professor Georgios B. Giannakis, from the University of Minnesota. I am pleased to have such a high profile speaker with a strong background in signal processing across a wide range of applications. Georgios will describe signal processing techniques to handle massive datasets which are noisy, incomplete, vulnerable to cyber-attacks and have outliers. The growth of Big Data represents a major ongoing challenge for humanity. The derivation of suitable data processing techniques is a vital activity and I am especially looking forward to seeing what can be accomplished in this area. Georgios has had a long engagement with the conference having acted as part of the technical committee as early as 1993 and presented his first paper at Asilomar in 1988.

I am privileged to have served as this year's General Chair. I hope that you enjoy the 2014 Conference programme whilst taking some time out to encounter the very special environment and atmosphere that Asilomar has to offer.

Prof. Roger Woods
Queen's University Belfast, UK, June 2014

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2014 Asilomar Conference Session Schedule

Sunday Afternoon, November 2, 2014

3:00–7:00 PM	Registration — Merrill Hall
4:00–6:30 PM	Student Paper Contest — Heather
7:00–9:00 PM	Welcoming Dessert Reception — Merrill Hall

Monday Morning, November 3, 204

7:30–9:00 AM	Breakfast – Crocker Dining Hall
8:00 AM–6:00 PM	Registration
8:15–9:45 AM	MA1a — Conference Welcome and Plenary Session — Chapel
9:45–10:15 AM	Coffee Social

10:15–11:55 AM MORNING SESSIONS

MA1b	Learning and Optimization for Big Data
MA2b	EEG Based Brain Computer Interface
MA3b	Underwater Wireless Networks
MA4b	Physical Layer Security I
MA5b	Image and Video Processing
MA6b	Sparse Estimation and Learning in Multi-Channel and Array Systems
MA7b	Architectures for Detection and Decoding
MA8b1	Synchronization and Channel Estimation (Poster)
MA8b2	Relaying (Poster)
MA8b3	Active Sensing and Target Recognition (Poster)
MA8b4	Physiological Signal Processing (Poster)

12:00–1:00 PM	Lunch – Crocker Dining Hall

Monday Afternoon, November 3, 2014

1:30–5:10 PM AFTERNOON SESSIONS

MP1a	Big Data Analytics
MP1b	Tensor-Based Signal Processing
MP2a	Neural Engineering and Signal Processing
MP2b	Brain Connectomics
MP3a	Compressed Sensing I
MP3b	Compressed Sensing II
MP4a	Underwater Acoustic Communications and Networking
MP4b	Massive MIMO I
MP5a	Smart Grid: Learning and Optimization
MP5b	Image and Video Quality
MP6a	Array Calibration
MP6b	Wireless Localization
MP7a	Resource-aware and Domain-specific Computing
MP7b	Detection and Estimation for Networked Data
MP8a1	Network Resource Allocation and Localization (Poster)
MP8a2	Bioinformatics and Medical Imaging (Poster)
MP8a3	Source Separation and Array Processing (Poster)
MP8a4	Digital Communications (Poster)
MP8a5	Image and Speech Processing (Poster)

Monday Evening, November 3, 2014

6:00–9:30 PM Conference Cocktail/Social — Merrill Hall
The Cocktail/Social takes the place of Monday's dinner. No charge for conference attendees and a guest.

2014 Asilomar Conference Session Schedule
(continued)

Tuesday Morning, November 4, 2014

7:30–9:00 AM	Breakfast — Crocker Dining Hall
8:00 AM–5:00 PM	Registration

8:15–11:55 AM MORNING SESSIONS

TA1a	High Dimensional and Large Volume Data
TA1b	Big Data Signal Processing
TA2a	Neural Spike Train Analysis
TA2b	Dynamic Brain Functional Connectivity
TA3a	Distributed Optimization over Networks
TA3b	Latest Coding Advances
TA4a	Enhanced MIMO for LTE-A and 5G Systems
TA4b	Cognitive Radio I
TA5a	Recent Advances in Speech Coding
TA5b	Historic Photographic Paper Identification via Textural Similarity Assessment
TA6a	Compressive Methods in Radar
TA6b	Statistical Inference in Smart Grids
TA7a	Computer Arithmetic I
TA7b	MIMO Sensing
TA8a1	Channel Estimation and MIMO Feedback (Poster)
TA8a2	Image Processing I (Poster)
TA8a3	Signal Processing for Communications (Poster)
TA8a4	Adaptive Filtering (Poster)
TA8b1	Multiuser and Cellular Systems (Poster)
TA8b2	Computer Arithmetic II (Poster)
TA8b3	Array Processing Methods (Poster)
TA8b4	Compressed Sensing III (Poster)

12:00–1:00 PM	Lunch – Crocker Dining Hall

Tuesday Afternoon, November 4, 2014

1:30–5:35 PM AFTERNOON SESSIONS

TP1a	Covariance Mining
TP1b	Large-Scale Learning and Optimization
TP2a	Bioinformatics and DNA Computing
TP2b	Echo Cancellation
TP3a	Machine Learning
TP3b	Sparse Signal Recovery
TP4a	Optical Communications
TP4b	Energy Harvesting Wireless Communications
TP5a	Speech Enhancement
TP5b	Full Duplex MIMO Radio
TP6a	Passive and Multistatic Radars
TP6b	Many-Core Platforms
TP7a	Design Methodologies for Signal Processing
TP7b	Optical Wireless Communications
TP8a1	Cognitive Radio II (Poster)
TP8a2	Signal Processing Methods (Poster)
TP8a3	Image Processing II (Poster)
TP8a4	Sensor and Wireless Networks (Poster)
TP8b1	Topics in Communication Systems (Poster)
TP8b2	Relays, Cognitive, Cooperative, and Heterogeneous Networks (Poster)
TP8b3	Signal Processing Architectures (Poster)
TP8b4	Signal Processing Theory and Applications (Poster)

Tuesday Evening **Open Evening — Enjoy the Monterey Peninsula**

2014 Asilomar Conference Session Schedule
(continued)

Wednesday Morning, November 5, 2014

7:30–9:00 AM	Breakfast — Crocker Dining Hall
8:00 AM–12:00 PM	Registration — Copyright forms must be turned in before the registration closes at 12:00 noon.
8:15–11:55 AM	MORNING SESSIONS

WA1a	MIMO Design for mmWave Systems
WA1b	Massive MIMO II
WA2a	5G and Energy Efficient Cellular Networks
WA2b	Mobile Health
WA3a	Sparse Learning and Estimation
WA3b	Advances in Statistical Learning
WA4a	Physical Layer Security II
WA4b	Coding and Decoding
WA5a	Information Processing for Social and Sensor Networks
WA5b	Document Processing and Synchronization
WA6a	Adaptive Signal Design and Analysis
WA6b	Distributed Detection and Optimization
WA7a	Implementation of Wireless Systems
WA7b	Video Coding Architecture and Design

12:00–1:00 PM	Lunch — Meal tickets may be purchased at registration desk. This meal is not included in the registration.

Student Paper Contest

Heather - Sunday, November 2, 2014, 4:00 - 6:30 PM

Track A	*"Everlasting Secrecy in Disadvantaged Wireless Environments against Sophisticated Eavesdroppers"* **Azadeh Sheikholeslami**, Dennis Goeckel, Hossein Pishro-nik, UMASS-Amherst, United States *"On Physical Layer Secrecy of Collaborative Compressive Detection"* **Bhavya Kailkhura**, Thakshila Wimalajeewa, Pramod Varshney, Syracuse University, United States
Track B	*"Max-Min Fairness in Compact MU-MIMO Systems: Can the Matching Network Play a Role?"* **Yahia Hassan**, Armin Wittneben, ETH Zurich, Switzerland
Track C	*"On the Convergence Rate of Swap-collide Algorithm for Simple Task Assignment"* **Sam Safavi**, Usman A. Khan, Tufts University, United States *"Secrecy Outage Analysis of Cognitive Wireless Sensor Networks"* **Satyanarayana Vuppala**, Jacobs University Bremen, Germany; Weigang Liu, Tharmalingam Ratnarajah, University of Edinburgh, United Kingdom; Giuseppe Abreu, Jacobs University Bremen, Germany
Track D	*"Subspace Learning from Extremely Compressed Measurements"* **Martin Azizyan**, Akshay Krishnamurthy, Aarti Singh, Carnegie Mellon University, United States *"Abstract Algebraic-Geometric Subspace Clustering"* **Manolis Tsakiris**, Rene Vidal, Johns Hopkins University, United States
Track E	*"Calibrating Nested Sensor Arrays with Model Errors"* **Keyong Han**, Peng Yang, Arye Nehorai, Washington University in St. Louis, United States
Track F	*"Whitening 1/f-type Noise in Electroencephalogram Signals for Steady-State Visual Evoked Potential Brain-Computer Interfaces"* **Alan Paris**, Azadeh Vosoughi, George Atia, University of Central Florida, United States
Track G	*"Hybrid Floating-Point Modules with Low Area Overhead on a Fine-Grained Processing Core"* **Jon Pimentel**, Bevan Baas, University of California, Davis, United States
Track H	*"Crowdsourced Study of Subjective Image Quality"* **Deepti Ghadiyaram**, Alan Bovik, University of Texas at Austin, United States

Coffee breaks will be at 9:55 AM and 3:10 PM. (except Monday morning when refreshments will be served outside Chapel from 9:45–10:15 AM)

Monday, November 3, 2014

CONFERENCE OPENING AND PLENARY SESSION 8:15 – 9:45 AM, LOCATED IN CHAPEL

1. Welcome from the General Chairperson:

Prof. Roger Woods
Queen's University of Belfast

2. Session MA1a Distinguished Lecture for the 2014 Asilomar Conference

Learning Tools for Big Data Analytics

Prof. Georgios B. Giannakis
University of Minnesota, USA

Abstract
We live in an era of data deluge. Pervasive sensors collect massive amounts of information on every bit of our lives, churning out enormous streams of raw data in various formats. Mining information from unprecedented volumes of data promises to limit the spread of epidemics and diseases, identify trends in financial markets, learn the dynamics of emergent social-computational systems, and also protect critical infrastructure including the smart grid and the Internet's backbone network. While Big Data can be definitely perceived as a big blessing, big challenges also arise with large-scale datasets. The sheer volume of data makes it often impossible to run analytics using a central processor and storage, and distributed processing with parallelized multi-processors is preferred while the data themselves are stored in the cloud. As many sources continuously generate data in real time, analytics must often be performed "on-the-fly" and without an opportunity to revisit past entries. Due to their disparate origins, massive datasets are noisy, incomplete, prone to outliers, and vulnerable to cyber-attacks. These effects are amplified if the acquisition and transportation cost per datum is driven to a minimum. Overall, Big Data present challenges in which resources such as time, space, and energy, are intertwined in complex ways with data resources. Given these challenges, ample signal processing opportunities arise. This keynote lecture outlines ongoing research in novel models applicable to a wide range of Big Data analytics problems, as well as algorithms to handle the practical challenges, while revealing fundamental limits and insights on the mathematical trade-offs involved.

Biography
Georgios B. Giannakis received his Diploma in Electrical Engineering from the National Technical University of Athens, Greece, 1981. From 1982 to 1986 he was with the University of Southern California, where he received his MSc. in Electrical Engineering (1983), MSc. in Mathematics (1986), and Ph.D. in Electrical Engineering (1986). He became a Fellow of the IEEE in 1997. Since 1999, he has been a Professor with the University of Minnesota where he now holds an ADC Chair in Wireless Telecommunications in the ECE Department, and serves as director of the Digital Technology Center. His general interests span the areas of communications, networking and statistical signal processing – subjects on which he has published more than 370 journal papers, 630 conference papers, 20 book chapters, two edited books and two research monographs (h-index 108). Current research focuses on sparsity and big data analytics, wireless cognitive radios, mobile ad hoc networks, renewable energy, power grid, gene-regulatory, and social networks. He is the (co-) inventor of 22 patents issued, and the (co-) recipient of 8 best paper awards from the IEEE Signal Processing (SP) and Communications Societies, including the G. Marconi Prize Paper Award in Wireless Communications. He also received Technical Achievement Awards from the SP Society (2000), from EURASIP (2005), a Young Faculty Teaching Award, and the G. W. Taylor Award for Distinguished Research from the University of Minnesota. He is a Fellow of EURASIP, and has served the IEEE in a number of posts, including that of a Distinguished Lecturer for the IEEE-SP Society.

Program of 2014
Asilomar Conference
on
Signals, Systems, and Computers

Technical Program Chairman
Prof. Geert Leus
Delft University of Technology

Track D – Signal Processing and Adaptive Systems

Session: MAb1 – Learning and Optimization for Big Data

Co-Chairs: ***Konstantinos Slavakis,*** *University of Minnesota* ***and Nicholas D. Sidiropoulos,*** *University of Minnesota*

MA1b-1 10:15 AM

FLEXA: A Fast Parallel Algorithm for Big-Data Optimization

Francisco Facchinei, Simone Sagratella, University of Rome, Italy; Gesualdo Scutari, University of Buffalo, the State University of New York, United States

We propose a decomposition framework for the parallel optimization of the sum of a differentiable function and a (block) separable nonsmooth, convex one. The latter term is usually employed to enforce structure in the solution, typically sparsity. Our framework is very flexible and includes both fully parallel Jacobi schemes and Gauss-Seidel (i.e., sequential) ones, as well as virtually all possibilities "in between" with only a subset of variables updated at each iteration. Our theoretical convergence results improve on existing ones, and numerical results on LASSO and logistic regression problems show that the new method consistently outperforms existing algorithms.

MA1b-2 10:40 AM

Fast and Robust Bootstrap in Analysing Large Multivariate Datasets

Shahab Basiri, Esa Ollila, Visa Koivunen, Aalto University, Finland

In this paper we investigate applications of fast and robust boostrapping (Salibian-Barrera and Zamar, 2002) in analysing large volume and high-dimensional data sets. Smaller datasets are resampled from the original data set with replacement. The full data set may be comprised of subsets stored in many locations because of its large volume. Conventional bootstrap estimators are particularly sensitive to outliers. Hence, statistically robust approximate bootstrap estimates and confidence intervals are computed by solving fixed-point estimating equations for multivariate data. The considered estimators have bounded loss functions and are quantitatively robust having a high breakdown point. Confidence intervals may be used for identifying sparseness present in high-dimensional signals. Different resampling strategies are considered obtaining the bootstrap estimates. Different strategies for combining the estimates from resample realizations are considered. Statistical properties of the estimators are established and their computational complexity is studied as well.

MA1b-3 11:05 AM

Clustering High-Dimensional Dynamical Systems on Low-Rank Matrix Manifolds

Konstantinos Slavakis, X. Wang, G. Lerman, University of Minnesota, United States

Based on the low-rank representation ability of autoregressive moving average (ARMA) models, this paper introduces a novel algorithm for clustering ARMA modeled high-dimensional dynamical systems into submanifolds placed on low-rank matrix manifolds. Sparse coding and the tangent spaces of the underlying manifold are utilized to reveal the low-dimensional structure of the observed data. Such structure is efficiently employed by spectral clustering to segment data into clusters which are even allowed to intersect. Extensive validation on real data demonstrates the superior performance of the proposed method over state-of-the-art techniques on important action identification applications.

MA1b-4 11:30 AM

Adaptive Estimation from Big Data via Censored Stochastic Approximation

Dimitrios Berberidis, University of Minnesota, Twin Cities, United States; Gang Wang, Beijing Institute of Technology, China; Georgios Giannakis, Vassilis Kekatos, University of Minnesota, Twin Cities, United States

The era of ''Big Data'' is undoubtedly upon us with 2.5 quintillion bytes of data generated every day. Nonetheless, a significant percentage of the data accrued can be ''thrown away'' or ''reduced'' while maintaining a certain quality of statistical inference. By capitalizing on data redundancy, interval censoring is leveraged here to cope with the scarcity of resources needed for exchanging, storing, and processing Big Data. Using censored data, a novel online maximum likelihood algorithm is developed that is shown to be convergent in the mean and mean-square error sense. Simulated tests corroborate its efficacy relative to competing alternatives.

Track F – Biomedical Signal and Image Processing

Session: MAb2 – EEG Based Brain Computer Interface

Chair: ***Murat Akcakaya,*** *Northeastern University*

MA2b-1 10:15 AM

Decoding the Focus of Auditory Attention from Single-Trial EEG Signals

Lenny Varghese, Inyong Choi, Siddharth Rajaram, Courtney Pacheco, Barbara Shinn-Cunningham, Boston University, United States

Auditory stimuli produce attention-modulated responses detectable from electroencephalography (EEG) signals. The focus of attention to individual elements within a sound mixture can be determined from these signals if sound “streams” are temporally decorrelated from one another. We discuss the physiological origins of these brain signals, ongoing work in towards decoding these signals on a “single trial” basis, and how such results compare to decoding EEG signals using visual stimuli.

MA2b-2 10:40 AM

Auditory Considerations for a Motor Imagery Brain-Computer Interface for Speech Synthesizer Control

Jonathan Brumberg, Jeremy Burnison, University of Kansas, United States

We report on a sensorimotor rhythm (SMR) brain-computer interface (BCI) for controling a speech synthesizer with instantaneous auditory output. Subjects first listen to three acoustically presented vowel stimuli while imagining three different limb movements. Subjects then repeat the sounds using the BCI- synthesizer under motor imagery control. Using an adaptive filter technique, the decoder predicts and synthesizes vowel features from the SMR for auditory output. Here we focus on the implications of auditory perception on control of the BCI, specifically, whether users rely on BCI output that is perceptually equivalent to the stimulus rather than an exact replication.

MA2b-3 11:05 AM

Single-Trial Identification of Failed Memory Retrieval

Eunho Noh, University of California, San Diego, United States; Matthew Mollison, Tim Curran, University of Colorado Boulder, United States; Virginia de Sa, University of California, San Diego, United States

We show that it is possible to distinguish unsuccessfully retrieved from successfully retrieved studied items based on single-trial scalp EEG activity recorded during the test phase of 3 separate recognition memory experiments. The likelihood of remembering a study item for trials with the 10% highest and lowest classifier outputs were 0.80 and 0.45 respectively. This suggests that the classifier outputs are reflecting the level of retrieval during the test phase. These findings combined with previous single-trial results predicting successful memory encoding from EEG recorded during the study phase will provide a basis for a passive BCI system for improving memory.

MA2b-4 11:30 AM

Utilization of Temporal Trial Dependency in ERP based BCIs

Umut Orhan, CorTech, LLC, United States; Delia Fernandez-Canellas, Universitat Politècnica de Catalunya, Spain; Murat Akcakaya, Dana H. Brooks, Deniz Erdogmus, Northeastern University, United States

In most event related potential (ERP) based brain computer interfaces (BCI) that utilizes electroencephalography (EEG), features corresponding to the stimuli are extracted after the application of a window covering the expected duration of the response. Especially for the paradigms with shorter inter stimulus interval compared to the expected duration of the response, such an approach not only causes dependencies of the consecutive trials to be lost but also might decrease the efficiency of the utilization of the temporal information in the signal. Alternative to the classical approach, we propose a graphical model that considers the dependency between consecutive trials to make more informed decisions based on the characteristics of the signal. Additionally, we propose modeling and identification of the system from visual stimuli to EEG to potentially increase the efficiency of utilization of the temporal information.

Session: MAb3 – Underwater Wireless Networks

Chair: ***Milica Stojanovic,*** *Northeastern University*

MA3b-1 10:15 AM

On the Feasibility of Fully Wireless Remote Control for ROVs

Federico Favaro, Filippo Campagnaro, Paolo Casari, Michele Zorzi, University of Padova, Italy

In this paper, we explore the possibility of controlling a Remotely Operated Vehicle (ROV) via a fully wireless control channel. As a first step, we review the expected bit rate offered by optical, acoustic as well as radio-frequency underwater communication technologies, as a function of the distance between the transmitter and the receiver. We then discuss the Quality-of-Service (QoS) requirements of services offered by a typical ROV and discuss which can be supported by a given technology at a given distance. Finally we simulate the performance of the system during missions of interest, and conclude by discussing the effectiveness of wireless control methods for ROVs.

MA3b-2 10:40 AM

Modeling Realistic Underwater Acoustic Networks using Experimental Data

Mandar Chitre, Gabriel Chua, National University of Singapore, Singapore

Since underwater network experiments are logistically challenging and expensive to conduct, many researchers evaluate the performance of their protocols through simulation. The validity of simulation results strongly depends on the accuracy of the channel model used. We use data from underwater network experiments to model the spatiotemporal variability of network performance. This approach allows researchers to test protocols in realistic simulation environments driven by representative experimental datasets, long after the experiments are conducted.

MA3b-3 11:05 AM

Scalable Collision-Tolerant Localization in Underwater Acoustic Sensor Networks

Hamid Ramezani, Geert Leus, Technical University of Delft, Netherlands; Milica Stojanovic, Northeastern University, United States

In this paper, we consider the joint problem of packet scheduling and localization in a multi-hop underwater acoustic sensor network where the anchors and sensor nodes are distributed in an operating area at random. Briefly, the anchors broadcast their packets with a known probability density function, e.g., Poisson distribution. Based on its communication range, each sensor node collects the successfully received packets, and uses them for self-localization. Taking into account the interference power, collision probability, and noise power, the proposed scheme adjusts the anchors' packet transmission rate in such a way that each sensor node in the network can localize itself with a predefined probability. Here, we will focus on the simplicity of the implementation, localization time, and probability of successful self-localization.

MA3b-4 11:30 AM

New Frontiers in Underwater Acoustic Communications

Andrew Singer, Thomas Riedl, University of Illinois at Urbana Champaign, United States

This talk will discuss one of the most challenging digital communications channels on the planet, the underwater acoustic channel. Through aggressive use of signal processing and forward error correction, a number of highly successful methods have been developed in our research group for achieving unprecedented data rates through the underwater acoustic medium. When an underwater acoustic modem is installed on a mobile platform such as an underwater vehicle, a buoy, or a surface vessel, Doppler effects distort the acoustic signal significantly. The acoustic path between a surface vessel and an underwater vehicle, for example, can experience Mach numbers of one percent and more which can be catastrophic if not compensated dynamically. We derive a sample-by-sample, recursive resampling technique, in which time-varying Doppler is explicitly modeled, tracked and compensated. Integrated into an iterative turbo equalization-based receiver, this novel Doppler compensation technique achieves unprecedented communication performance in field tests and simulations. Some of our field data stems from the MACE10 experiment conducted in the shallow waters 100 km south of Martha's Vineyard, MA. Under challenging conditions (harsh multi-path, ranges up to 7.2 km, SNRs down to 2 dB and relative speeds up to 3 knots) we obtained a data rate of 40 kbits/s using 10 kHz of bandwidth. Additional experimental results will be discussed from at-sea tests as well as tests in our acoustic communications tanks on campus. This talk will also cover the essential elements of joint equalization and decoding, or so-called turbo equalization and the essential role that it plays in making these systems robust and effective.

Track A – Communications Systems

Session: MAb4 – Physical Layer Security I

Chair: ***Pramod Varshney,*** *Syracuse University*

MA4b-1 10:15 AM

On Physical Layer Secrecy of Collaborative Compressive Detection

Bhavya Kailkhura, Thakshila Wimalajeewa, Pramod Varshney, Syracuse University, United States

This paper considers the problem of collaborative compressive detection under a physical layer secrecy constraint. More specifically, we consider the problem where the network operates in the presence of an eavesdropper who wants to discover the state of the nature being monitored by the system. It is shown that, the security performance of the system can be improved by using cooperating trustworthy nodes that assist the Fusion Center (FC) by providing falsified data to the eavesdroppers. We also consider the problem of determining optimal system parameters which maximize the detection performance at the FC, while ensuring perfect secrecy at the eavesdropper.

MA4b-2 10:40 AM

Converse Results for Secrecy Generation over Channels

Himanshu Tyagi, University of California, San Diego, United States; Shun Watanabe, University of Tokushima, Japan

We revisit the problem of secret key agreement in channel models, where in addition to a noisy, albeit secure channel, the terminals have access to a noiseless public communication channel. We show a strong converse for the secret key capacity in the point-to-point model and give upper bounds for the general case. Underlying our proofs is a recently discovered single-shot converse for secret key rates in multiterminal source models.

MA4b-3 11:05 AM

Robust Transmission over Wiretap Channels with Secret Keys

Rafael F. Schaefer, H. Vincent Poor, Princeton University, United States

The compound wiretap channel models the problem of secure communication under channel uncertainty in the presence of an eavesdropper who must be kept ignorant of transmitted messages. In this paper, the compound wiretap channel with secret keys is studied, where transmitter and legitimate receiver share an additional secret key of a fixed rate. This paper studies how the channel uncertainty and the secret key influence the corresponding secrecy capacity.

MA4b-4 11:30 AM

Secret Key-Private Key Generation for Multiple Terminals

Huishuai Zhang, Syracuse University, United States; Lifeng Lai, Worcester Polytechnic Institute, United States; Yingbin Liang, Huishuai Zhang, Syracuse University, United States

The problem of simultaneously generating a secret key (SK) and private key (PK) pair among multiple terminals is studied, in which each terminal observes a component of correlated sources. All terminals are required to generate a common secret key concealed from an eavesdropper that has access to public discussion, while two designated terminals are required to generate an extra private key concealed from both the eavesdropper and the remaining terminals. Bounds on the SK-PK capacity region are derived for the general case. For pairwise independent network (PIN model), the SK-PK capacity region is established.

Track H – Speech, Image and Video Processing

Session: MAb5 – Image and Video Processing

Chair: ***Marios S. Pattichis,*** *University of New Mexico*

MA5b-1 10:15 AM

Robust Image Recognition by Multi-Kernel Dictionary Learning

Rituparna Sarkar, Sedat Ozer, Scott Acton, Kevin Skadron, University of Virginia, United States

Many recent studies discussed the problem of selecting and combining the salient features from a pool of feature-types and showed that such techniques yield higher accuracy on average than only selecting features from a single feature-type in image retrieval and classification applications. In this paper, we approach this problem as selection of the salient feature-types from a

pool of feature-types rather than selecting the individual features. Our approach utilizes multiple kernels within the dictionary-learning framework where a combination of dictionary atoms represents individual categories and category specific feature combination parameters and weights are determined by the multiple kernel technique.

MA5b-2 10:40 AM

Robust Dual-Band MWIR/LWIR Infrared Target Tracking

Chuong Nguyen, Joseph Havlicek, University of Oklahoma, United States; Guoliang Fan, Oklahoma State University, United States; John Caulfield, Cyan Systems, United States; Marios Pattichis, University of New Mexico, United States

We introduce an SIR particle filter for tracking civilian targets including vehicles and pedestrians in dual-band midwave/longwave infrared imagery as well as a novel dual-band track consistency check for triggering appearance model updates. Because of the paucity of available dual-band data, we constructed a custom sensor to acquire the test sequences. The proposed algorithm is robust against magnification changes, aspect changes, and clutter and successfully tracked all 17 cases tested, including two partial occlusions. Future work is needed to comprehensively evaluate performance of the algorithm against state-of-the-art video trackers, especially considering the relatively small number of previous dual-band tracking results that have appeared.

MA5b-3 11:05 AM

Crowdsourced Study of Subjective Image Quality

Deepti Ghadiyaram, Alan Bovik, University of Texas at Austin, United States

We designed and created a new image quality database that models diverse realistic image distortions and artifacts that affect images that are captured using modern mobile devices. We also designed and implemented a new online crowdsourcing system, which we are using to conduct a very large-scale, on-going, multi-month image quality assessment (IQA) subjective study, wherein a wide range of diverse observers record their judgments of image quality. Our database currently consists of over 220,000 opinion scores on 1,163 characteristically distorted images evaluated by over 5000 human observers.

MA5b-4 11:30 AM

Detecting Coronal Holes for Solar Activity Modeling

Marios Pattichis, University of New Mexico, United States; Rachel Hock, AFRL/RVBXS Space Vehicles Directorate, United States; Venkatesh Jatla, University of New Mexico, United States; Carl Henney, Charles Arge, AFRL/RVBXS Space Vehicles Directorate, United States

The paper focuses on the development of coronal hole detection methods for use in physical models of solar activity. The problem is motivated from the need to provide physical models with accurate detection of coronal holes. For each method, we use a new optimization approach for determining the best parameter values. Optimization is based on a new matching metric that compares clusters of automatically detected coronal holes against a manually annotated database. Validation of the approach is performed on the manually annotated database using leave-one-out.

Track E – Array Signal Processing

Session: MAb6 – Sparse Estimation and Learning in Multi-Channel and Array Systems

Co-Chairs: ***Palghat P. Vaidyanathan,*** *California Institute of Technology* ***and Piya Pal,*** *University of Maryland*

MA6b-1 10:15 AM

Characterization of Orthogonal Subspaces for Alias-Free Reconstruction of Damped Complex Exponential Modes in Sparse Arrays

Pooria Pakrooh, Ali Pezeshki, Louis L. Scharf, Colorado State University, United States

In this work, we consider the problem of parameter estimation for p damped complex exponentials, from the observation of non-uniform samples of their weighted and damped sum. This problem arises in many areas such as modal analysis, speech processing, system identification and direction of arrival estimation. For the case of DOA estimation, it is shown that for specific choices of sparse sensor geometries such as coprime and nested arrays the DOA problem is identifiable using MUSIC. We are interested in the estimation of the mode parameters through characterization of the orthogonal subspace of the generalized Vandermonde matrix associated with the signal component of the sensor measurements. This characterization becomes useful when we are interested in maximum likelihood or least squares estimation of the modes from noisy measurements. Here, we can

use iterative quadratic maximum likelihood or modified least squares to come up with a 2p-parameter characterization of the orthogonal subspace. After estimating the parameters representing the orthogonal subspace, we find the roots of two polynomials associated with these coefficients and match up the roots. We show that for certain sparse geometries, such as the coprime array, matching up the roots removes aliasing and yields the actual modes in the noise-free case. Also, we derive the stochastic Cramer-Rao Bound (CRB) in the estimation of the mode parameters. In the special case of DOA estimation, we look for the best array geometries that minimize the CRB in a certain SNR region. We study the sensitivity of our parameterization of the orthogonal subspace to sensor location errors. This can be considered another factor in determining the best geometries for sparse arrays. Naturally, all of our developments also apply to estimation of complex exponential modes from time series data.

MA6b-2 10:40 AM

Exploiting Sparsity during the detection of High-Order QAM Signals in Large Dimension MIMO Systems

Oleg Tanchuk, Bhaskar Rao, University of California, San Diego, United States

This paper proposes a receiver for multiple-input multiple-output (MIMO) systems for various constellation sizes and channel knowledge at the receiver. The detector is composed of multiple stages. During the first stage, linear MMSE filter is employed and nearest neighbor quantization is performed resulting in a sub-optimal estimate. During the next stage, the residual in the measurement vector is calculated and the detector focuses on the error vector which has additional structure. The all-zero vector and lowest energy vectors have the largest priors. As a result the error vector is often sparse (has few non-zero components), allowing sparse signal recovery techniques such as Sparse Bayesian Learning to be employed during the detection step. Large number of antennas allows Gaussian approximations to take effect, simplifying and minimizing some of the dependencies between error and noise vectors.

MA6b-3 11:05 AM

Structured Sparse Representation with Low-Rank Interference

Minh Dao, Yuanming Suo, Sang (Peter) Chin, Trac Tran, Johns Hopkins University, United States

This paper provides an efficient framework for multiple-measurement representation where the underlying signals exhibit sparsity properties over some proper dictionaries but the measurements are largely corrupted by interference sources. Under assumption that the interference component forms a low-rank structure, the proposed model extracts the interference by minimizing its nuclear norm while simultaneously promoting structured-sparsity representation of multiple correlated signals. An efficient algorithm based on alternating direction method of multipliers is also proposed. Extensive experiments are conducted on various applications: hyperspectral chemical plume classification, robust speech recognition in noisy environments, and synthetic aperture radar image recovery to verify the method’s effectiveness.

MA6b-4 11:30 AM

Grid-Less Algorithms for Identifying More Spectral Lines Than Sensors.

Piya Pal, University of Maryland, College Park, United States; P. P. Vaidyanathan, California Institute of Technology, United States

We consider the problem of estimating the sparse spectrum of a signal from only a few samples measured at a sub-Nyquist rate. We specifically consider the situ- ation where the signal exhibits a line spectrum. Considering a Wide Sense Stationary signal model, the authors had previously proposed novel sampling techniques that could identify O(M^2) spectral lines using only O(M) samples. Recently, the authors have proposed a new approach exploiting the low rank structure of the covariance matrix, to identify these O(M^2) spectral lines. This new method does not suffer from basis mismatch, nor does it need to know the number of spectral lines apriori. In this paper, we study the performance of the proposed low rank minimization approach, especially when correlation estimates deviate from their ideal values and/or when they are corrupted with additive noise. We also demonstrate how other grid-less algorithms, such as “atomic norm minimization” or “TV-norm minimization” can be adopted to identify O(M^2) spectral lines using suitable sub- Nyquist sampling schemes, and compare their performance both analytically and empirically. The results in this paper extend a series of recent work on convex optimization based approaches for sparse line spectrum estimation, by improving the guarantees on the number of resolvable lines through the use of suitable sampling schemes.

Track G – Architecture and Implementation

Session: MAb7 – Architectures for Detection and Decoding

Chair: ***Joseph R. Cavallaro,*** *Rice University*

MA7b-1 10:15 AM

A Reduced-Complexity Iterative Decoding Scheme for Quasi-Cyclic Low-Density Parity-Check Codes

Shu Lin, Keke Liu, Juane Li, University of California, Davis, United States

Quasi cyclic low-density parity-check (QC-LDPC) codes are the most preferred type of LDPC codes for error control in communication and data storage systems due to their encoding and decoding implementation advantages over the other types of LDPC codes. This paper presents a reduced-complexity iteratively revolving decoding scheme for QC-LDPC codes which is devised based on the quasi-cyclic structure of the parity-check matrices of these codes. A high-rate and long QC-LDPC code is used to demonstrate the effectiveness of the proposed decoding scheme.

MA7b-2 10:40 AM

Efficient Adaptive List Successive Cancellation Decoder for Polar Codes

Chuan Zhang, National Mobile Communications Research Laboratory, China; Zhongfeng Wang, Broadcom Corporation, United States; Xiaohu You, National Mobile Communications Research Laboratory, China

Because of their ability to provably achieve symmetric capacities of binary-input discrete memory-less channels (B-DMCs), polar codes have been receiving significant attentions from researchers. In this paper, an adaptive list successive cancellation (SC) decoder is proposed for polar codes. In the proposed list decoder, the maximum list size L_max is fixed, but the actual utilized list size L can be adaptively reduced once the setup threshold metric is met. Simulation results show that the proposed adaptive list decoder achieves similar performance as that of the classic list decoder, whereas requires less computation complexity. The hardware architecture for the proposed decoder is also proposed. Compared to the existing adaptive scheme for polar decoders, the proposed approach turns out to be more implementation friendly.

MA7b-3 11:05 AM

Decoder Diversity Architectures for Finite Alphabet Iterative Decoders for LDPC Codes

Bane Vasic, University of Arizona, United States; David Declercq, Universite de Cergy-Pontoise, France; Shiva Planjery, Codelucida, United States

We present a finite alphabet iterative decoders (FAIDs), a new type of decoders for low-density parity check (LDPC) codes, which outperform much more complex belief-propagation-based counterparts in the error floor region. The FAID variable node update is a simple Boolean map, and we show that by varying this map one can achieve a class of decoders capable of correcting wide range of distinct error patterns uncorrectable by a single FIAD. We call this concept decoding diversity, and present a low-complexity architecture and error performance analysis of the FAID diversity decoder for column-weight three LDPC codes using only hard-decisions from the channel.

MA7b-4 11:30 AM

Asynchronous Design for Precision-Scaleable Energy-Efficient LDPC Decoder

Jingwei Xu, Tiben Che, Ehsan Rohani, Gwan Choi, Texas A&M university, United States

This paper presents a low-density parity-check (LDPC) decoder design that uses scalable-precision calculation (SPC) and asynchronous circuit techniques to reduce power consumption. The decoder configures the computation precision to minimize circuit-level switching necessary for given target bit-error rate. The asynchronous circuit approach guarantees the completion of each compute-and-forward phase at necessary voltage levels. The voltage level is scheduled to ensure completion of minimum necessary decoding iterations. The proposed scheme is studied for the specific application of WiMAX to reduce the power consumption at a desired quality of service (QoS). The proposed design is implemented and evaluated on Nangate 45nm library.

Session: MAb8 – Synchronization and Channel Estimation 10:15 AM–11:55 AM

Chair: ***Shengli Zhou,*** *University of Connecticut*

MA8b1-1

Frequency Tracking with Intermittent Wrapped Phase Measurement Using the Rao-Blackwellized Particle Filter

Maryam Eslami Rasekh, Upamanyu Madhow, University of California, Santa Barbara, United States; Raghuraman Mudumbai, University of Iowa, United States

We consider the problem of frequency and phase tracking with intermittent measurements. Since accurate one-shot frequency estimation requires long measurement epochs, to minimize overhead, we consider using phase-only measurements. Based on the concept of a Rao-Blackwellized particle filter, a particle filter is utilized to deduce the unwrapped phase from the wrapped phase measurements, while an extended Kalman filter (EKF) estimates the frequency offset and provides phase predictions that are used to update particle weights. By jittering the timing of measurement epochs, frequency aliasing due to phase wrapping is disambiguated. The efficacy of the proposed method is demonstrated on measured data.

MA8b1-2

Improving IEEE 1588v2 Time Synchronization Performance with Phase Locked Loop

Rico Jahja, Suk-seung Hwang, Goo-Rak Kwon, Jae-young Pyun, Seokjoo Shin, Chosun University, Indonesia

IEEE 1588 is one of the packet-based clock synchronization protocols. Different clock quality in each device will cause inaccurate clock synchronization. In order to mitigate such kind of error, Phase Locked Loop (PLL) could be the solution of it. In this paper, we propose a method that is consisted of the combination of IEEE 1588 and PLL to mitigate both queuing delay variation from the network congestion as well as clock error because of the clock drift. The experiments show that our method achieved sub-microsecond clock accuracy in faster period than the existing method.

MA8b1-3

Superimposed Pilots based Secure Communications for Multiple Antenna System

Yejian Chen, Bell Laboratories, Alcatel-Lucent, Germany

In this paper, we investigate secure communications by introducing superimposed pilots for multiple antenna system. The superimposed pilots enable the trellis-based joint channel tracking and data detection for the user of interest. Further, by adjusting the power ratio between the data symbol and superimposed pilot symbol, the secure capacity region can be established. The user of interest can appropriately select the Forward Error Correction (FEC) code rate, to prevent any possible eavesdropping. In this paper, we present the achievable secure capacity region for multiple antenna system, and verify it via Monte Carlo simulation as well.

MA8b1-4

An Improved ESPRIT-Based Blind CFO Estimation Algorithm In OFDM Systems

Yen-Chang Pan, See-May Phoong, National Taiwan University, Taiwan; Yuan-Pei Lin, National Chiao Tung University, Taiwan

Carrier frequency offset (CFO) is an important issue in orthogonal frequency division multiplexing (OFDM) systems. It destroys the orthogonality between subcarriers and causes degradation in system performance. This paper presents an improved algorithm for the existing ESPRIT-based CFO estimation method. The proposed method estimates the CFO by taking the determinant of a matrix within the ESPRIT algorithm. It is a simple modification to the original ESPRIT-based method and its computational overhead is low. The performance analysis shows that the proposed method can achieve a lower mean square error.

MA8b1-5

Blind, Low Complexity Estimation of Time and Frequency Offsets in OFDM Systems

Rohan Ramlall, University of California, Irvine, United States

A novel blind time and frequency offset estimator for orthogonal frequency division multiplexing (OFDM) systems is presented. The estimator exploits a basic assumption of OFDM: the channel order is less than or equal to the length of the cyclic prefix. Under this assumption, it is shown that the last sample of the received cyclic prefix is not corrupted by intersymbol interference (ISI) and this sample can be used to estimate the time of arrival (TOA) in multipath channels. It is demonstrated that the proposed estimator identifies the correct TOA with a higher probability than existing estimators for medium to high signal-to-noise ratios.

MA8b1-6
Efficient NLOS Optical Wireless Channel Estimation based on Sparse Pulse
Xiaoke Zhang, Chen Gong, Zhengyuan Xu, University of Science and Technology of China, China

We study the channel estimation problem for the non-line of sight (NLOS) optical wireless communications with coherent phase optical sources, for example Laser signals. Such channel estimation problem is fundamentally different from the conventional channel estimation problem for wireless electro-magnetic communication, since only the squared norm of the channel finite-length filter output is observed from the received signal. Thus the channel estimation methods for wireless electro-magnetic communication cannot be applied. We propose a sparse pilot pulse-based channel estimation method, and the corresponding preliminary numerical results. Further optimization of the proposed channel estimation remains for our work in the next step.

MA8b1-7
Channel Estimation and Precoder Design for Millimeter-Wave Communications: The Sparse Way
Philip Schniter, Ohio State University, United States; Akbar Sayeed, Wisconsin, United States

We propose spectrally and computationally efficient methods for space-time channel estimation and precoding applicable to millimeter-wave communication systems, which operate at high frequencies (30-300 GHz) over large bandwidths (>1 GHz). Our methods exploit the fact that such channels are much sparser (in both angle and delay domains) than their microwave counterparts, allowing accurate channel estimation from relatively few measurements. Furthermore, they leverage the MIMO virtual-channel model, fast algorithms to compute its coefficients, and aperature-domain windowing methods to ensure its sparsity.

Track B – MIMO Communications and Signal Processing
Session: MAb8 – Relaying 10:15 AM–11:55 AM
Chair: ***Guiseppe Caire,*** *TU Berlin*

MA8b2-1
Performance Analysis of Fixed Gain MIMO AF Relaying with Co-Channel Interferences
Min Lin, Min Li, PLA University of Science and Technology, China; Wei-Ping Zhu, Concordia University, Canada; Kang An, PLA University of Science and Technology, China

This paper investigates the outage performance of a two-hop multiple-input and multiple-output (MIMO) amplify-and-forward (AF) relay network. Specifically, by applying the MRT and MRC for the transmitter and receiver of each hop, respectively, we first obtain the output signal-to-interference-plus-noise ratio with multiple co-channel interferences (CCIs) and noise at the relay. Then, we present the closed-form outage probability (OP) expression of the consider AF relay network. Finally, computer simulations are provided to demonstrate the validity of the derived theoretical formulas, and indicate the effects of antenna combinations, CCI and power allocation on the outage performance of the consider two-hop AF relaying.

MA8b2-2
On Carrier-Cooperation in Parallel Gaussian MIMO Relay Channels with Partial Decode-and-Forward
Christoph Hellings, Wolfgang Utschick, Technische Universität München, Germany

It is known that parallel relay channels are not separable, i.e., the capacity with joint processing of the subchannels can be higher than the sum of the individual capacities. The same holds for the data rates achievable using partial decode-and-forward with Gaussian input signals. However, in this paper, we show that for parallel Gaussian MIMO relay channels, it is sufficient to allow the relay to remap information from one subchannel to another between the decoding and the re-encoding. A carrier-cooperative transmission in the sense of spreading transmit symbols over several subchannels does not bring advantages in terms of achievable rate.

MA8b2-3
Enhanced Relay Cooperation via Rate Splitting
Ivana Maric, Dennis Hui, Ericsson, United States

In wireless networks, mixed cooperative strategies in which relays in favorable positions decode-and-forward and the rest quantize via short message noisy network coding (SNNC) have been shown to outperform existing cooperative strategies (e.g., decode-and-forward or compress-and-forward). We propose a novel relaying scheme that improves the performance of such

mixed cooperative strategies. In the proposed scheme, superposition coding is incorporated into SNNC encoding to enable partial interference cancellation at DF relays. The achievable rate with proposed scheme is derived for the discrete two-relay network and evaluated in the Gaussian case where gains over the rate achievable without rate splitting are demonstrated.

MA8b2-4
Alternate versus Simultaneous Relaying in MIMO Cellular Relay Networks: A Degrees of Freedom Study
Aya Salah, Amr El-Keyi, Nile University, Egypt; Mohammed Nafie, Cairo University, Egypt

A two-hop cellular relay network consisting of two source-destination pairs equipped with M antennas is considered where each source is assisted by two decode-and-forward relays operating in half-duplex mode and the relays are equipped with N antennas. The DoF of the system is investigated for both simultaneous and alternate relaying configurations. For each relay configuration, an outer bound on the degrees of freedom (DoF) is developed. A new achievable scheme is proposed that meets the upper bound on the maximum DoF for all values of M and N except for $M<N<5M/2$.

MA8b2-5
Low-Complexity Two-Way AF MIMO Relay Strategy for Wireless Relay Networks
Kanghee Lee, Republic of Korea Air Force, Republic of Korea; Visvakumar Aravinthan, Sunghoon Moon, Wichita State University, United States; Jongbum Ryou, Sungo Kim, Changki Moon, Inha Hyun, Republic of Korea Air Force, Republic of Korea

In this paper, a two-way amplify-and-forward (AF) wireless relay network consisting of two sources with multiple M antennas and one relay with multiple N antennas is investigated with a self-interference cancelation process. The relay amplifying matrix that has the low computational complexity is optimized under the relay transmit power constraint based on zero-forcing (ZF) criterion with a singular value decomposition (SVD) method. The sum rate behavior is analytically and numerically studied. Numerical results show that the eigen beamforming is more competitive than the equal-gain beamforming for the two-way relaying systems.

MA8b2-6
Blind Self-Interference Cancellation for Full-Duplex Relays
Gustavo Gonzalez, Fernando Gregorio, Juan Cousseau, CONICET - Universidad Nacional del Sur, Argentina

Full-duplex relays improve spectral efficiency but transmission and reception in the same frequency band produce coupling between the transmitter and receiver side signals. This self-interference requires to be removed to allow a proper operation. The cyclic prefix employed in modern modulations produces a periodic autocorrelation that is perturbed by the relay coupling. We propose a criterion, and an associated blind adaptive algorithm, to estimate the self-interference that employs the known autocorrelation pattern of the source signal as a reference. We present an study of the mean squared error of the criterion and analyze the stationary points of the algorithm.

Track E – Array Signal Processing
Session: MAb8 – Active Sensing and Target Recognition 10:15 AM–11:55 AM
Chair: ***Mark R. Bell,*** *Purdue University*

MA8b3-1
Proximal Constrained Waveform Design Algorithms for Cognitive Radar STAP
Pawan Setlur, Wright State Research Institute, United States; Muralidhar Rangaswamy, Air Force Research Laboratory, United States

Waveform design is an important component of the fully adaptive radar construct. In this paper we consider waveform design for radar space time adaptive processing (STAP), accounting for the waveform dependence of the clutter correlation matrix. Due to this dependence, in general, the joint problem of receiver weight vector optimization and radar waveform design becomes an intractable optimization problem. We derive proximal constrained algorithms which, at each step, optimizes the STAP weight vector and waveform independently. Unlike traditional STAP techniques, these algorithms are numerically stable, and can be used in the practical training data starved STAP scenarios. Our simulations reveal a non-increasing error variance at the output of the filter.

MA8b3-2

The Generalized Sinusoidal Frequency Modulated Waveform for High Duty Cycle Active Sonar

David Hague, John Buck, University of Massachusetts Dartmouth, United States

High Duty Cycle Active Sonar (HDCAS) continuously transmits waveforms and processes target echoes to revisit the target scene more often than conventional pulsed active sonar. The main challenge in HDCAS waveform design is to maintain large instantaneous bandwidth while revisiting the target scene often. This research proposes a new diverse pulse train for HDCAS that is composed of Generalized Sinusoidal Frequency Modulated (GSFM) waveforms. Since each GSFM waveform in the pulse train is nearly orthogonal to the others, each pulse can be processed separately providing the high target revisit rates necessary for HDCAS while also attaining large instantaneous bandwidth.

MA8b3-3

Concurrent Exploration of Orthogonal Waveform and Co-Prime Array for Quick and High Resolution Scanning

Shuo Yang, Xin Wang, Xuehong Lin, Stony Brook University, United States

Co-prime array has been introduced lately to achieve O(MN) degree of freedom with M+N sensors. In existing studies on the application of co-prime array, each or both sub-arrays of a co-prime array work in coherent mode where all the antennas of an array transmit the same signal. In this work, we would like to investigate the potential benefit of using orthogonal waveform transmissions like that done MIMO radar case in co-prime array. In particular, we apply the co-prime array for signal scanning, and our analysis indicates that the use of the two techniques can significantly speed up the scanning process.

MA8b3-4

On Bayesian Transmit Signal Design using Information Theory

Mir H. Mahmood, NextNav LLC, United States; Mark R. Bell, Purdue University, United States

A signal design problem that maximizes the mutual information between the received signal and target impulse response under Bayes decision theoretic framework is investigated. Owing to its analytical intractability, a new approximate problem is formulated, and its solution presented in the form of a fixed point signal design equation along with an efficient numerical algorithm to design MI-maximizing signals. The energy allocation of the designed signals is compared to SNR-maximizing signals. Simulation results of the detection performance show that while SNR-maximizing signals provide overall better detection performance, MI-maximizing signals provide better conditional detection performance for less dominant target classes.

MA8b3-5

Improved Distributed Automatic Target Recognition Performance by Exploiting Dominant Scatterer Spatial Diversity

John Wilcher, William Melvin, Georgia Tech Research Institute, United States; Aaron Lanterman, Georgia Institute of Technology, United States

Radar automatic target recognition (ATR) is examined from the viewpoint of improving classification performance through spatial diversity. Recent radar target classification performance improvements have been confirmed using multiple target reflectivity returns. This paper extends the use of multiple target looks by examining the impact of dominant scatterer placement and physical characteristics on target classification rates. Multiple, spatially diverse high range resolution (HRR) profiles are exploited to show progressive improvement in classification rates as such additional target perspectives are included in the classification algorithm. Percentage of correct classification (PCC) improvements exceeding 10% is demonstrated.

MA8b3-6

Semi-Supervised Classification of Terrain Features in Polarimetric SAR Images using H/A/alpha and the General Four-Component Scattering Power Decompositions

Stephen Dauphin, Sandia National Laboratories, United States; Margaret Cheney, Colorado State University, United States; Derek West, Robert Riley, Sandia National Laboratories, United States

In an effort to enhance image segmentation and classification of terrain features in a fully polarimetric SAR image, this paper explores the utility of the ordered coupling of SLIC superpixel segmentation of the General Four-Component Scattering Power decomposition multi-channel product with a subsequent H/A/alpha decomposition on resulting superpixels. The resulting superpixels can be classified into discrete terrain feature categories by comparing them to hand-picked reference samples using a semi-supervised routine.

MA8b3-7

A Super-Resolving Near-Field Holographic Method for Underwater EM Signature Modeling

Hatim Alqadah, Naval Research Laboratory, United States; Nicolas Valdivia, US Naval Research Laboratory, United States

This work is concerned with fast and stable back-projection of near-field electromagnetic array measurements in underwater environments. Such procedures are used for near-real time prediction of underwater structure radiation patterns. The conductivity of the water introduces severe instability due to the presence of evanescent waves in the data. We demonstrate a stable super-resolution technique based on a sparse decomposition of the measurements into a finite sum of elementary electric and/or magnetic dipole sources. The resulting sparse regularization objective function is minimized via fast iterative thresholding methods. Back -projection results using experimental underwater AC and DC range data are presented.

MA8b3-8

Limitations and Capabilities of the Fractional Spectrogram Analysis Tool for SAR-Based Detection of Multiple Vibrating Targets

Adebello Jelili, Balu Santhanam, Majeed Hayat, University of New Mexico, United States

SAR-based detection and estimation of vibration signatures of ground objects using the micro-Doppler effect has gained attention in recent work [4,6,9,10]. Ground target vibrations that introduce phase modulation in the SAR return signals are examined using standard pre-processing, followed by analysis via the recently introduced fractional spectrograms [8]. The capabilities and limitations of this new time-frequency analysis tool, for multiple vibrating target detection and classification, are investigated.

Track F – Biomedical Signal and Image Processing

Session: MAb8 – Physiological Signal Processing 10:15 AM–11:55 AM

Chair: ***Alessio Medda,*** *Georgia Tech*

MA8b4-1

Sample-Based Cross-Frequency Coupling Analysis with CFAR Detection

Charles Creusere, Nathan McRae, Mark Norman, Philip Davis, New Mexico State University, United States

In the proposed paper, we introduce a new approach for cross-frequency coupling analysis as applied to electroencephalograph (EEG) signals. Our approach consists of a low-complexity signal analysis block which is well-suited to implementation as an integrated circuit followed by constant false alarm rate (CFAR) detection. In the preliminary results presented here, we see that the proposed framework provides good detection while effectively rejecting false alarms. In the final paper, we will include full receiver operating curves (ROCs) as well for more precise validation.

MA8b4-2

Classification of Human Viewers using SVM

Philip Davis, Charles Creusere, Jim Kroger, New Mexico State University, United States

Subject identification and authentication using electroencephalograph (EEG) signals has been gaining interest in the biometric field due to the decrease in price in EEG systems and the extremely positive results that researchers have seen. Here, we evaluate biometric identification using linear support vector machine (SVM) classification on subjects watching short video clips. In particular, cepstral coefficient feature vectors are formed for each of the 128-channels of our EEG system. We explore the effects on classification of using individual versus grouped channels, different video types, and number of channels used. Furthermore, we also consider which regions of the head give the best classification results.

MA8b4-3

Activity Recognition using Statistical Gait Parameters from a Single Accelerometer

Andrew Vaughan, Alessio Medda, Brian Liu, Shean Phelps, Georgia Tech Research Institute, United States

Wearable sensor systems represent an increasingly viable approach to short and long term motion classification and gait estimation primarily due to decreased size, cost and broad applicability. A simple model of an acceleration response, acquired during different levels and types of activities, was obtained using statistical mixture models. The proposed algorithm uses this information to categorize activity in order to achieve the goal of estimating human performance through motion classification and gait estimation. Mixture parameters obtained from the signal of a single chest-worn accelerometer are used in a semi-supervised learning approach allowing for the robust classification of gait across subjects.

MA8b4-4

Intra-Patient and Inter-Patient Seizure Prediction from Spatial-Temporal EEG Features

Shuoxin Ma, Daniel Bliss, Arizona State University, United States

In this paper, an algorithm for intra-patient and inter-patient seizure prediction from invasive electroencephalography (EEG) is proposed. Multi-channel EEG are pre-processed and built into spatial-temporal covariance matrices, from which multivariate features are extracted. A support vector machine~(SVM) is trained with the features of classified data to predict the un-classified data. The cross-validation shows that the proposed algorithm achieves an outstanding performance, with the area under receiver operating characteristic~(ROC) curve of 0.977 for intra-patient and 0.822 for inter-patient prediction. The significance test further proves that the result is reliable, with p-values of 0.00 and 0.10 for intra-patient and inter-patient prediction, respectively.

MA8b4-5

Effective Connectivity in fMRI from Mutual Prediction Approach

Marisel Villafañe-Delgado, Selin Aviyente, Michigan State University, United States

Estimation of effective connectivity in neurophysiological signals has gained great popularity in recent years. Widely used, Granger causality depends on the temporal precedence of the signal’s amplitude and assumes the signals are linear and stationary. In this work an alternative model-free method for estimation of effective connectivity based on the signal’s instantaneous phases is assessed. Mutual prediction approach is implemented by estimating the instantaneous phases from the Reduced Interference Rihaczek time-frequency distribution. Results on both simulated and fMRI data indicate that the proposed method is comparable to Granger’s causality.

MA8b4-6

Whitening 1/f-type Noise in Electroencephalogram Signals for Steady-State Visual Evoked Potential Brain-Computer Interfaces

Alan Paris, Azadeh Vosoughi, George Atia, University of Central Florida, United States

A method is proposed to whiten 1-f-type background noise in electroencephalogram data by a non-linear spectral transformation from the frequency domain to a newly-defined alpha-pitch domain. Based on the alpha-pitch spectra of steady-state visual evoked potentials, an algorithm called octave-averaged spectral rectification is applied which simultaneously attenuates 1-f noise while enhancing resonance peaks. This has important potential benefits for gamma-band brain-computer interfaces.

MA8b4-7

Adaptive Learning of Behavioral Tasks for Patients with Parkinson’s Disease Using Signals from Deep Brain Stimulation

Nazanin Zaker, University of Denver, United States; Arindam Dutta, Alexander Maurer, Arizona State University, United States; Jun Zhang, University of Denver, United States; Sara Hanrahan, Adam Hebb, Colorado Neurological Institute, United States; Narayan Kovvali, Antonia Papandreou-Suppappola, Arizona State University, United States

We propose adaptive learning methods for identifying different behavioral tasks of patients with Parkinson’s disease (PD). The methods use local field potential signals that were collected during Deep Brain Stimulation implantation surgeries. Using time-frequency signal processing methods, features are first extracted and then clustered using two different methods. The first method uses a hybrid model that combines support vector machines and hidden Markov models. The second method does not require any a priori information and uses Dirichlet process Gaussian mixture models. We demonstrate the performance of both methods and discuss the advantages of each method under different conditions.

Track D – Signal Processing and Adaptive Systems

Session: MPa1 – Big Data Analytics

Chair: ***Ali Tajer,*** *Rensselaer Polytechnic Institute*

MP1a-1 1:30 PM

Universal Sequential Outlier Hypothesis Testing

Yun Li, Sirin Nitinawarat, Venugopal Veeravalli, University of Illinois at Urbana-Champaign, United States

Multiple observation sequences are collected, a few of which are outliers. Observations in an outlier sequence are generated by a different mechanism from that generating the typical sequences. The goal is to design a universal test to best discern the outlier sequences with the fewest observations on average. This problem was treated by us previously in the fixed sample size setting with an arbitrary number of outliers [1], and in the sequential setting with at most one outlier [2]. In this work, our previous findings are generalized to the sequential setting with multiple outliers.

MP1a-2 1:55 PM

Parsimonious Models for Random Variables and Stochastic Processes

Weiyu Xu, University of Iowa, United States

In this paper, we will discuss various parsimonious models for random variables and random processes. High dimensional data generated from this model can be described by low-dimensional parameters. We will further discuss how to leverage these parsimonious models in signal processing applications, including network tomography and sparse principal component analysis.

MP1a-3 2:20 PM

Fundamental Limits on Information-Friction Energy of Big-Data Computing

Majid Mahzoon, Pulkit Grover, Carnegie Mellon University, India

Big-Data processing consumes a non-negligible fraction of world energy. This work provides fundamental limits on info-friction energy of example Big Data computations.

MP1a-4 2:45 PM

Quickest Search Over Correlated Sequences

Ali Tajer, Wayne State University, United States

This paper considers the problem of searching over a collection of sequences that are generated by one of the two possible distributions F_0 and F_1 and designs the quickest sequential detection procedure for identifying one sequence that is generated according to F_1. Generation of the sequences obeys a known dependency kernel such that the prior probability that a sequence is generated by F_1 is governed by the distributions of the rest of sequences. The optimal quickest sequential detection procedure, that is the procedure that strikes a balance between detection quality and decision delay as two opposing performance measures, is characterized.

Track D – Signal Processing and Adaptive Systems

Session: MPb1 – Tensor-Based Signal Processing

Chair: ***Eric Moreau,*** *University of Toulon*

MP1b-1 3:30 PM

Memory-Efficient Parallel Computation of Tensor and Matrix Products for Big Tensor Decomposition

Niranjay Ravindran, Nicholas Sidiropoulos, Shaden Smith, George Karypis, University of Minnesota, United States

Low-rank tensor decomposition has many applications in signal processing and machine learning, and is becoming increasingly important for analyzing big data. An significant challenge is the computation of the intermediate products which can be much larger than the final result of the computation, or even the original tensor. We propose a scheme that effectively allows in-place updates of intermediate matrices. We also propose a memory-efficient tensor compression scheme. The resulting algorithms can be parallelized, and do not require sparsity -- although it can be exploited if present.

MP1b-2 3:55 PM

Recent Advances on Tensor Models and their Relevance for Multidimensional Data Processing

Salah Bourennane, Julien Marot, Ecole Centrale Marseille - Institut Fresnel, France

This paper is mainly focused on reducing various types of noise in hyperspectral images. Several denoising methods based on tensor models, such as Tucker and PARAFAC, are proposed for different types of random noise in hyperspectral images. They can not only obtain great denoising performances but also preserve the rare signals in hyperspectral images.

MP1b-3 4:20 PM

Tensor-Based Channel Estimation for Non-Regenerative Two-Way Relaying Networks with Multiple Relays

Jianshu Zhang, Kristina Naskovska, Martin Haardt, Ilmenau University of Technology, Germany

In this paper we investigate a two-way relaying network with multiple amplify-and-forward relays where both the user terminals (UTs) and the relays can have multiple antennas. To improve the system performance, the UTs need channel knowledge of all relevant channels. Therefore, we propose a tensor-based channel estimation method based on the block component decomposition (BCD) as well as the CANDECOMP/PARAFAC (CP) decomposition. The proposed method is analytic, i.e., iterations are not required. We also derive the design criteria for the corresponding relay amplification matrices and the training sequences. Simulation results demonstrate the performance of the proposed channel estimation method.

MP1b-4 4:45 PM

Fast Non-Unitary Simultaneous Diagonalization of Third-Order Tensors

Victor Maurandi, Eric Moreau, University of Toulon, France

We consider the problem of non-orthogonal joint diagonalization of a set of real-valued third-order tensors. This appears in many signal processing problems and it is instrumental in source separation. We propose a new Jacobi-like algorithm based on a special parameterization of the so-called diagonalizing matrix. One important point is that each Jacobi estimation parameters is done entirely analytic using an appropriate criterion and based on an alternate estimation. Numerical simulations illustrate the overall very good performances of the proposed algorithm.

Track F – Biomedical Signal and Image Processing

Session: MPa2 – Neural Engineering and Signal Processing

Chair: ***Ervin Sejdic,*** *University of Pittsburgh*

MP2a-1 1:30 PM

Electroencephalography-based Alzheimer's Disease Diagnosis: Where we are at Now and Where we are Heading

Tiago Falk, Institut National de la Recherche Scientifique, Canada

This paper will present an overview of existing electroencephalography (EEG) based Alzheimer's disease (AD) diagnosis tools, along with their limitations and advantages. Examples will be given from both an ERP (event related potential) and a quantitative EEG perspective. The paper will conclude with a roadmap of possible future multimodal tools that can be developed with emerging technologies, such as functional Transcranial Doppler sonography (fTCD-EEG) and functional near-infrared spectroscopy (fNIRS-EEG).

MP2a-2 1:55 PM

EEG Event Detection Using Big Data

Iyad Obeid, Amir Harati, Joseph Picone, Temple University, United States

Although signal processing has attempted for reading EEGs, these efforts have mostly yielded poor results. These algorithms, based largely on heuristic methods or trained on modest data sets, have lacked the statistical power to adequately generalize their performance over the great variability seen in the clinic. Here, we present our efforts to overcome these limitations by using machine learning algorithms that are trained on a Big Data corpus comprising over 22,000 clinical recordings made in the Neurology department at Temple University Hospital over a ten-year span.

MP2a-3 2:20 PM

A Source Localization Approach to Creating a Neural Interface with the Peripheral Nervous System

Jose Zariffa, Toronto Rehabilitation Institute - University Health Network, Canada

Selectively monitoring the messages encoded in the electrical activity of peripheral nerves would enable us to improve the control of neuroprosthetic devices, which interface with the nervous system to help restore function after neurological injuries. By using multi-contact nerve cuff electrodes, which measure the electric potentials at several locations on the surface of the nerve, we can approach this task as an inverse problem of source localization. We will review our group's foundational work on this problem in a rat sciatic nerve model, and present recent developments.

MP2a-4 2:45 PM

A Picture is Worth a Thousand Words: Some Examples of the Utility of Biomedical Image Processing in Brain Research

Negar Memarian, University of California, Los Angeles, United States

Investigating the neural bases of various behaviors, emotions, neurological diseases, or neuropsychological disorders is a widely studied and yet very mysterious realm of research. Technical advances in structural and functional neuroimaging have spurred the development of sophisticated analysis techniques. In this talk, I explain the rationale for use of quantitative approaches in brain image analysis and draw examples from my interdisciplinary research collaboration with neuroscientists to illustrate the promise of signal/image processing and pattern recognition for achieving a more objective and accurate knowledge of the human brain.

Track F – Biomedical Signal and Image Processing

Session: MPb2 – Brain Connectomics

Chair: ***Dimitri Van De Ville,*** *EPFL*

MP2b-1 3:30 PM

Brain-Network Continua Revealed with Multivariate Performance Metrics.

Stephen Strother, Baycrest and University of Toronto, Canada

The brain is thought to contain a hierarchy of "networks" that dynamically reconfigure themselves to meet task demands. Evidence for such hierarchies in BOLD fMRI data sets has emerged from our attempts to build a quantitative framework for comparing the performance of multivariate pattern analysis models (e.g., linear discriminants (LD), support vector machines (SVM), logistic regression (LR)). I will describe the pseudo-Receiver Operating Characteristic performance plot defined by subsampled measures of prediction (P) plotted against spatial reproducibility (R) that is central to such performance measurements. Using these (P, R) plots as a function of model regularization we have shown that the choice and tuning of regularisation is generally more important than the particular linear model chosen. Moreover, we have also demonstrated that LD models regularized with dimensionality reduction using principal components (PC) are particularly well suited to reveal task-dependent hierarchies in the brain's covarying network structure. During task performance an LD model regularized with PCs added in order of largest to smaller variance traces out a characteristic (P, R) curve shape as a function of the number of PCs (q). Such (P, R) curves typically start with Pmin equivalent to random guessing for q=1, and rise to a task-dependent Pmax for q ▯ [20,100]. Values of R typically start near Rmax for q=1, decline and then reach a local maximum before Pmax, and then decrease rapidly with increasing q. I will compare and contrast the (P, R) curves of several related tasks with different levels of difficulty. Finally I will present evidence that the resulting normalized, spatial salience profiles as a function of increasing P and q reflect the regional hierarchies of the underlying brain-network continua adapted to meet particular task demands.

MP2b-2 3:55 PM

Learning with Multi-Site fMRI Graph Data

Gabriel Castrillon, Seyed-Ahmad Ahmadi, Nassir Navab, Technische Universität München, Germany; Jonas Richiardi, Stanford University, United States

Neuroimaging data collection is very costly, and acquisition is commonly distributed across multiple sites. However, factors such as different noise characteristics or inhomogeneities make it difficult to successfully combine multi-site functional imaging data. Correlation estimators necessary for computing functional connectivity graphs can also be sensitive to extreme signal values. Here, we propose to find a stable subspace by using a discriminative projection that does not only minimise site differences, but also preserves discriminative class information. We compare our method with the "regressing-out" approach on synthetic and real data.

MP2b-3 4:20 PM

Using Computer Vision to Understand Biological Vision

Dmitri Chklovskii, Simons Center for Data Analysis, United States

How do the networks of neurons in our brain give rise to our behavior, feelings, and thoughts? In attacking this question we follow the strategy used in reverse engineering of computer chips. We image brain structure at nanometer resolution and, by using computer vision algorithms, reconstruct neuronal wiring diagrams, or connectomes. Then, by using recent algorithms from signal processing and online learning, we infer the function of these connectomes. By applying this strategy to the simpler brain of a fruit fly we have made significant progress towards understanding its visual system, a small but efficient and powerful computing device.

MP2b-4 **4:45 PM**

Dynamic Functional Connectivity: Probing Spontaneous Network Reorganization

Dimitri Van De Ville, Nora Leonardi, École Polytechnique Fédérale de Lausanne / University of Geneva, Switzerland

Functional connectivity (FC) during resting state has already revealed significant insights into functional integration of the brain during task, but also at rest. However, increasing evidence points towards continuously fluctuating FC across the duration of a scan. Using unsupervised learning techniques, groups of co-evolving connections, or reproducible patterns of dynamic FC (dFC), have been revealed in fluctuating FC. In particular, based on results from k-means clustering and sliding-window correlations, it has recently been hypothesized that dFC may cycle through several discrete FC states. Alternatively, it has been proposed to represent dFC as a linear combination of multiple FC patterns using principal component analysis. As it is unclear whether sparse or non-sparse combinations of FC patterns are most appropriate, the goal of our study was to evaluate the impact of sparsity by performing an empirical evaluation of simulated, task-based and resting-state dFC. Therefore, we applied sparse matrix factorization methods for which we varied the sparsity constraints and then studied accuracy, reproducibility and stability of ensuing representations of dFC. During subject-driven tasks, dFC was well described by alternating FC states in accordance with the nature of the data. The estimated FC patterns showed a rich structure with combinations of known functional networks enabling accurate identification of the three different tasks. During rest, dFC was better described by multiple FC patterns that overlap. The executive control networks, which are critical for working memory, appeared grouped alternately with externally- or internally-oriented networks. These results suggest that sparse combinations of FC patterns can provide an economical and meaningful solution to disentangle resting-state dFC.

Track D – Signal Processing and Adaptive Systems

Session: MPa3 – Compressed Sensing I

Chair: ***Aleksandar Dogandzic,*** *Iowa State University*

MP3a-1 **1:30 PM**

Robust Line Spectral Estimation

Gongguo Tang, Colorado School of Mines, United States; Parikshit Shah, Badri Bhaskar, University of Wisconsin-Madison, United States; Benjamin Recht, University of California, Berkeley, United States

Line spectral estimation is a classical signal processing problem that finds numerous applications in array signal processing and speech analysis. We propose a robust approach for line spectral estimation based on atomic norm minimization that is able to recover the spectrum exactly even when the observations are corrupted by arbitrary but sparse outliers. The resulting optimization problem is reformulated as a semidefinite program. Our work extends previous work on robust uncertainty principles by allowing the frequencies to assume values in a continuum rather than a discrete set.

MP3a-2 **1:55 PM**

On the Applicability of Matrix Completion on MIMO Radars

Shunqiao Sun, Athina Petropulu, Rutgers University, United States

It was recently shown that networked MIMO radars with sparse sensing and matrix completion (MC) can significantly reduce the volume of data required for accurate target detection and estimation. This paper studies the applicability of MC theory on the data matrices that arise in colocated MIMO radars using uniform linear arrays. It is shown that the coherence is directly related to transmit waveforms, and that when the waveforms are orthogonal the optimum choice is for them to be white noise-type functions.

MP3a-3 **2:20 PM**

Subspace Learning from Extremely Compressed Measurements

Martin Azizyan, Akshay Krishnamurthy, Aarti Singh, Carnegie Mellon University, United States

We consider learning the principal subspace of a large set of vectors from an extremely small number of compressive measurements of each vector. Our theoretical results show that even a constant number of measurements per column suffices to approximate the principal subspace to arbitrary precision, provided that the number of vectors is large. This result is achieved by a simple algorithm that computes the eigenvectors of an estimate the covariance matrix. The main insight is to exploit an averaging effect that arises from applying a different random projection to each vector. We provide a number of simulations confirming our theoretical results.

MP3a-4 2:45 PM

Analysis of Misfocus Effects in Compressive Optical Imaging

Wenbing Dang, Ali Pezeshki, Randy Bartels, Colorado State University, United States

In this paper, we investigate the effect of misfocus on the performance of compressive optical imaging. Misfocus exists either because the object is out of focus, relative to the focal plane of the optical system, or because the object is extended along the optical axis. We derive theoretical bounds on the error in reconstructing the sparse field, as a function of demagnification and misfocus. Our numerical results show that compressed sensing is robust to misfocus at modest demagnification factors. However, at high demagnifications, which is typical in optical microscopy, compressive imaging performance degrades considerably.

Track D – Signal Processing and Adaptive Systems

Session: MPb3 – Compressed Sensing II

Chair: ***George Atia,*** *University of Central Florida*

MP3b-1 3:30 PM

Filter Design for a Compressive Sensing Delay Estimation Framework

Misagh Khayambashi, Lee Swindlehurst, University of California, Irvine, United States

Compressive sensing aims to find efficient signal acquisition and recovery techniques with the aid of prior knowledge of the signal. While traditionally applied to sparse vectors, CS has been extended to analog signals with more general structures. The use of CS in delay-Doppler estimation has recently received attention. We adopt a CS frameworks for delay-Doppler estimation and optimize the deployed filter. The optimization criterion is the Bayesian Cr\'amer Rao Bound of delay estimation. An iterative algorithm is proposed to solve the optimization problem and the results are compared with the prototype filter design.

MP3b-2 3:55 PM

Adaptive Sequential Compressive Detection

Davood Mardani, George Atia, University of Central Florida, United States

The problem of detecting the existence of a sparse signal in noise is considered. While it is well-established that significant compressive gains are achievable on account of sparsity, the question is whether further gains could be achieved when exact signal reconstruction is not necessary. In contrast to prior work, which considered non-adaptive strategies, a sequential adaptive feedback approach with a stopping rule is proposed for compressive signal detection. Two sources of gain are studied, namely,compression gains due to adaptation, and computational gains via effective algorithms that fuse newly acquired measurements and previous information.

MP3b-3 4:20 PM

A Recursive Way for Sparse Reconstruction of Parametric Spaces

Oguzhan Teke, Bilkent University, Turkey; Ali Cafer Gurbuz, TOBB University of Economics and Technology, Turkey; Orhan Arikan, Bilkent University, Turkey

A novel recursive framework for sparse reconstruction of continuous parameter spaces is proposed by adaptive partitioning and discretization of the parameter space together with expectation maximization type iterations. Any sparse solver or reconstruction technique can be used within the proposed recursive framework . Initial results show that proposed technique improves the parameter estimation performance of classical sparse solvers while achieving Cram\'er-Rao lower bounds on the tested problems. Final paper will present more detail on both the development of the algorithm and simulation results.

MP3b-4 4:45 PM

Subspace Methods for Recovery of Low Rank & Joint Sparse Matrices

Sampurna Biswas, Mathews Jacob, Soura Dasgupta, University of Iowa, United States

We consider the recovery of a low rank and jointly sparse matrix from under-sampled measurements of its columns. This is highly relevant in recovery of dynamic MRI data with high spatio-temporal resolution, where each column of the matrix correspond to a frame in the image time series; which is low-rank since the frames are highly correlated. Classical multiple measurement vector setup measures all the snapshots using the same matrix. We measure each snapshot using a different measurement matrix. We show that this reduces the total number of measurements, especially when the rank (X) is much smaller than than its sparsity.

Session: MPa4 – Underwater Acoustic Communications and Networking

Chair: ***Zhaohui Wang,*** *Michigan Technological University*

MP4a-1 1:30 PM

Experimental Study of Secret Key Generation in Underwater Acoustic Channels

Yi Huang, University of Connecticut, United States; Lifeng Lai, Worcester Polytechnic Institute, United States; Shengli Zhou, Zhijie Shi, University of Connecticut, United States

The predefined secret keys are often used to encrypt the data information in underwater acoustic (UWA) communications. However, it's not safe once the keys are stolen by eavesdroppers. We propose a new method that can generate secret keys dynamically based on the frequency measurements of the channel in orthogonal frequency-division multiplexing (OFDM) systems, where randomness and correlation of mutual channels are exploited to update the keys at regular intervals. Specifically, the amplitude of each tone is quantized to 1-bit information, resulting a correlated binary sequence. Then low-density parity-check (LDPC) codes are used to extract keys according to the Slepian-Wolf coding theorem. We will use experiment results to verify the randomness and correlation between channels, and show that the secret keys can be generated in a low speed due to the time-varying characteristics of UWA channels.

MP4a-2 1:55 PM

Random Linear Packet Coding for Fading Channels: Joint Power and Rate Control

Rameez Ahmed, Milica Stojanovic, Northeastern University, United States

Random linear packet coding is considered for channels that experience fading and have long propagation delay, such as the underwater acoustic channels. Previously, we employed power control (adjusting the transmission power according to the channel gain) and rate control (adjusting the number of coded packets according to the channel gain) to counteract the effects of fading. For such policies, it can be shown that there exists an optimal number of coded packets (when employing power control) or optimal transmission power (when employing rate control) for which the energy required per bit of information transmitted is minimized. In this paper, we present a strategy to jointly optimize the transmission power and the number of coded packets, such that the average energy per bit is minimized. We demonstrate the algorithm performance in simulation, as well as with experimental data from two at-sea experiments.

MP4a-3 2:20 PM

Underwater Acoustic Communications in Great Lakes and in Oceans: What is the Difference?

Wensheng Sun, Mohsen Jamalabdollahi, Zhaohui Wang, Seyed Zekavat, Michigan Technological University, United States

Underwater acoustic (UWA) communications and networking have drawn considerable attentions in last decades, while a majority of the research efforts have been paid to oceanic environment. Given that the Great Lakes occupy a shoreline of an approximately identical length as that of the US east coast, investigation on the UWA communication performance in Great Lakes is of great importance. Based on both numerical modeling and data sets collected in field experiments, this work characterizes the acoustic channel in Lake Superior in terms of the signal transmission loss and the channel multipath structure. By comparing the channel characteristics with that in oceans, an appropriate transceriver design for UWA communications in the Great Lakes is studied.

MP4a-4 2:45 PM

Information-Guided Pilot Insertion for Capacity Improvement in OFDM Underwater Acoustic Communications

Xilin Cheng, Colorado State University, United States; Miaowen Wen, Xiang Cheng, Peking University, China; Liuqing Yang, Colorado State University, United States

Knowledge of channel state information at the receiver is essential for the recovery of the information-conveying symbols. In OFDM underwater acoustic communication systems, acquisition of the channel state information is usually achieved with the aid of pilots. Unlike traditional OFDM underwater acoustic communication systems, where the pilot positions are fixed, we allow a random pilot insertion for the enhancement of the system spectral efficiency. In other words, the pilot positions will carry additional information. Correspondingly, we also design an adaptive detection mechanism at the receiver.

Session: MPb4 – Massive MIMO I

Chair: ***Erik Larsson,*** *Linköping University*

MP4b-1 3:30 PM

Jsdm and Multi-Cell Networks: Handling Inter-Cell Interference Through Long-Term Antenna Statistics

Ansuman Adhikary, University of Southern California, United States; Giuseppe Caire, Technical University Berlin, Germany

Joint Space Division and Multiplexing (JSDM) is a novel paradigm for clearly splitting the functions of multiuser MIMO precoding into the concatenation of blocks: a pre-beamforming projection that depends only on the channel long0term statistics (channel covariance matrices), and a precoder that achieve multiplexing gain over the effective channel including pre-beamforming. In our previous work, we showed that this structure is capacity achieving when the users can be grouped into sets with same covariance matrix, such that the dominant channel eigenspaces form a tall unitary basis. In addition, we showed that this case is always achieved in the massive MIMO limit (large number of antennas at the base station), and under some assumptions on the users and scattering environemnt distribution. Furthermore, JSDM is naturally suited for a hybrid implementation of massive MIMO, where the pre-beamforming matrix can be implemented in the analog RF domain. In this paper, we extend our study of JSDM to a multi-cell system, where the pre-beamforming projections are jointly selected across cells and together with user scheduling, such that inter-cell interference can be handled by using only the channel covariances (i.e., the so-called ``long-term'' antenna statistics), which are much easier to collect than the classical instantaneous channel state information.

MP4b-2 3:55 PM

Enabling Massive MIMO Systems in the FDD Mode thanks to D2D Communications

Haifan Yin, Laura Cottatellucci, David Gesbert, Eurecom, France

Massive MIMO systems offer an attractive solution in enhancing the data rate performance of wireless networks through the use of large arrays at the base station side. Such arrays offer high beamforming and interference mitigation capabilities without requiring complex inter-cell coordination approaches. By and large, such concepts have been confined to TDD systems due to the prohibitive cost of (i) estimating channels and (ii) conveying the information back to infrastructure, in non reciprocal setups like FDD. This paper offers a re-visit of this issue in the context of cellular networks enabled with some form of proximity D2D communication. We show how such D2D communications, when combined with recently unveiled statistical properties of large array channels, can help make massive MIMO amenable to an FDD implementation

MP4b-3 4:20 PM

Massive MIMO As a Cyber-Weapon

Erik G. Larsson, Linkoping University, Sweden; Marcus Karlsson, Linköping University, Sweden

Massive MIMO is a revolutionary technology in wireless access, where large numbers of coherently operating base station antennas serve many terminals in the same time-frequency resource via spatial multiplexing. Massive MIMO relies on channel reciprocity and TDD operation, where the base station learns the downlink channel from uplink training. In this paper we consider a scenario where massive MIMO technology falls in the hands of an adversary, who uses the large array of antennas to jam a conventional (primary) communication link that operates in TDD. The jammer adaptively learns the slot timing of the primary system, and estimates all channels within each coherence interval. It is shown that a low-output-power jammer can cause significant harm to the primary link, without prior knowledge of neither the propagation channels nor the slot timing.

MP4b-4 4:45 PM

Large Antenna Array and Propagation Environment Interaction

Xiang Gao, Meifang Zhu, Fredrik Rusek, Fredrik Tufvesson, Ove Edfors, Lund University, Sweden

In traditional MIMO, propagation conditions are often considered stationary over the entire antenna array. In massive MIMO systems, where arrays can span over large physical dimensions, the situation is quite different. For instance, significant variations in signal strength, due to shadowing, can be experienced across a large array. These effects vary with propagation environment, in which the array is placed, and influence achievable sum-rates. We characterize these variations for several measured propagation scenarios in the 2.6 GHz frequency range and illustrate how power variations and correlation properties change along the array.

Track C – Networks

Session: MPa5 – Smart Grid: Learning and Optimization

Chair: ***Gonzalo Mateos,*** *University of Minnesota*

MP5a-1 — 1:30 PM

Dynamic Attacks on Power Systems Economic Dispatch

Jinsub Kim, Lang Tong, Robert Thomas, Cornell University, United States

A dynamic data attack on a power system aimed at making the real time economic dispatch infeasible is considered. As a man-in-the-middle attack, the attack modifies part of meter measurements such that the control center is misled with an incorrect system state estimate, which affects the computation of real time economic dispatch. Two attack mechanisms are considered. The first is an opportunistic approach where the attacker waits for a chance of a successful attack and launches an attack in a single state estimation period. The second is a dynamic attack strategy where the attacker gradually drifts the system state toward the infeasible region for real time economic dispatch. The efficacy of the proposed attacks is demonstrated by numerical experiments with the IEEE 14-bus network and the IEEE 118-bus network.

MP5a-2 — 1:55 PM

Line Outage Detection in Power Transmission Networks Via Message Passing Algorithms

Jianshu Chen, University of California, Los Angeles, United States; Yue Zhao, Andrea Goldsmith, Stanford University, United States; H. Vincent Poor, Princeton University, United States

Detecting multiple simultaneous line outages in power transmission networks is known to be a challenging problem due to the number of hypotheses that grows exponentially with the network size. This paper proposes a low complexity message passing algorithm that exploits the sparse structure of the network topology in power systems. First, a factor graph is established that jointly characterizes the power system and the monitoring sensor network. Exploiting the power flow equations in power systems, novel techniques that extend the conventional message passing algorithms are developed. Simulation results demonstrate that the developed algorithm can effectively detect multiple simultaneous line outages.

MP5a-3 — 2:20 PM

Online Learning Approaches for Dynamic Optimal Power Flow

Seung-Jun Kim, Georgios Giannakis, University of Minnesota, United States

Optimal power flow is a critical control task for reliable and efficient operation of power systems. Significant challenges are anticipated in future power systems, as a substantial level of renewable generation and vehicle electrification is accommodated, imposing volatile and uncertain dynamics to the grid. In this work, online learning approaches, which do not require elaborate models and yet provide provable performance guarantees, are adopted to tackle dynamic optimal power flow. The efficacy of the proposed techniques is verified through numerical tests.

MP5a-4 — 2:45 PM

Decentralized Primary Frequency Control in Power Networks

Changhong Zhao, Steven Low, California Institute of Technology, United States

We augment existing generator-side primary frequency control with load-side control that are local, ubiquitous, and continuous. The mechanisms on both the generator and the load sides are decentralized in that their control decisions are functions of locally measurable frequency deviations. These local algorithms interact over the network through nonlinear power flows. We design the local frequency feedback control so that any equilibrium point of the closed-loop system is the solution to an optimization problem that minimizes the total generation cost and user disutility subject to power balance across entire network. With Lyapunov method we derive a sufficient condition ensuring an equilibrium point of the closed-loop system is asymptotically stable. Simulation demonstrates improvement in both the transient and steady-state performance over the traditional control only on the generators, even when the total control capacity remains the same.

Track H – Speech, Image and Video Processing

Session: MPb5 – Image and Video Quality

Chair: ***Pamela C. Cosman,*** *University of California, San Diego*

MP5b-1 3:30 PM

Real-Time 3D Rotation Smoothing for Video Stabilization

Chao Jia, Zeina Sinno, Brian Evans, University of Texas at Austin, United States

We propose two real-time motion smoothing algorithms for video stabilization using a 3D rotational camera motion model. Both algorithms aim at smoothing 3D rotation matrix sequences in a causal way. The first algorithm smooths the rotation sequences in a way similar to 1st-order IIR filtering. The second uses sequential probabilistic estimation under a constant angular velocity model. We exploit the manifold structure of the rotation matrices so that the proposed algorithms directly smooth the rotation sequences on the manifold. In addition, we introduce a projection step in order to guarantee that no black borders intrude into the stabilized video frames.

MP5b-2 3:55 PM

Joint Source-Channel Rate-Distortion Optimization with Motion Information Sharing for H.264/AVC Video-Plus-Depth Coding

Yueh-Lun Chang, University of California, San Diego, United States; Yuan Zhang, Communication University of China, China; Pamela Cosman, University of California, San Diego, United States

Video-plus-depth coding has been suggested as an efficient tool to support three-dimensional television. In this paper, we propose a motion information sharing encoding scheme with an end-to-end rate-distortion model for H.264/AVC coding of video-plus-depth sequences. Experimental results with the proposed encoding scheme show PSNR gains of up to 1 dB for the depth sequence under a packet loss environment.

MP5b-3 4:20 PM

Image Assisted Upsampling of Depth Map via Nonlocal Similarity

Wentian Zhou, Xin Li, Daryl Reynolds, West Virginia University, United States

The depth resolution of TOF cameras is poor and the resulting depth maps are noisy. Therefore, it is highly desirable to develop powerful image processing tools to enhance the resolution and suppress the noise of depth maps. In this paper, we propose a new image-assisted upsampling method for depth map. A spatially adaptive iterative singular-value thresholding (SAIST) with image-guided patch clustering strategy is developed and compared with previous image-guided depth map upsampling techniques. Overall, the proposed scheme is capable of better preserving salient global structure information. Extensive experimental results are reported to justify the superiority of the proposed method.

MP5b-4 4:45 PM

Video De-Interlacing Using Asymmetric Nonlocal-Means Filtering

Roozbeh Dehghannasiri, Texas A&M University, United States

This paper presents a de-interlacing method based on the nonlocal-means (NL-means) approach. In the NL-means, every interpolated pixel is set to a weighted combination of its neighboring pixels. We use an asymmetric NL-means scheme where the pixel in the neighborhood and the pixel being interpolated can be at the center or off-center of their patches. To calculate NL-means weights, we initially find estimates of patches using a spatio-temporal edge-based method which employs a risk function for interpolation. This function reflects the performance of the interpolation direction on the original adjacent pixels. Experimental results verify the superior performance of our method.

Track E – Array Signal Processing

Session: MPa6 – Array Calibration

Chair: ***Visa Koivunen,*** *Aalto University*

MP6a-1 1:30 PM

Bilinear Compressed Sensing for Array Self-Calibration

Benjamin Friedlander, University of California, Santa Cruz, United States; Thomas Strohmer, University of California, Davis, United States

We consider array self-calibration by joint estimation of directions-of-arrival and gain/phase parameters. Previous approaches were mainly based on eignestructure methods (such as MUSIC) which have difficulties with correlated sources and small number of snapshots. A different solution is presented here based on a sparse signal model and the use of mixed-norm minimization of a cost function. Two approaches are presented: one based on alternating minimization and the other on tensor completion. The proposed method does not have the disadvantages of eigenstructure based methods. It offers performance similar to that of maximum likelihood estimation but has a lower computational cost.

MP6a-2 1:55 PM

Calibrating Nested Sensor Arrays with Model Errors

Keyong Han, Peng Yang, Arye Nehorai, Washington University in St. Louis, United States

We consider the problem of direction of arrival (DOA) estimation based on a nonuniform linear nested array. In practice, the actual sensor gain and phase are often perturbed from their nominal values. In this paper, we investigate the calibration problem for perturbed nested arrays, proposing corresponding robust algorithms to estimate both the model errors and the DOAs. The partial Toeplitz structure of the covariance matrix is employed to estimate the gain errors, and the sparse total least squares is used to deal with the phase error issue. Numerical examples are provided to verify the effectiveness of the proposed strategies.

MP6a-3 2:20 PM

A New Method for DOA Estimation in the Presence of Unknown Mutual Coupling of an Antenna Array

Eric Wei-Jhong Ding, Borching Su, National Taiwan University, Taiwan

In this paper, we studied the problem of DOA estimation in the presence of mutual coupling. The proposed method for reconstructing the steering vector can estimate the DOAs in the situation of a large number of source signals with unknown mutual coupling. The main advantage of the proposed method is that the capacity of the number of source signals is higher than other methods in the case of high accuracy system model. Moreover, the proposed method can work well by applying the spatial smoothing technique even if source signals are coherent. Simulation results confirm the advantage of the proposed method.

MP6a-4 2:45 PM

An Angular Sampling Theorem for the Usable Frequency Range of Antenna Array Calibration Measurements

Chung-Cheng Ho, Scott Douglas, Southern Methodist University, United States

For high precision direction-finding using antenna arrays, a highly-accurate calibration data set is required. This paper focuses on the sampling requirements of such data sets to ensure an accurate direction-of-arrival (DOA) estimate, in which interpolation across angle and frequency is assumed. Limited discussions of this issue can be found in the literature, and a quantified procedure to avoid aliasing has not been presented. We establish a link between calibration angle spacing and the maximum operational frequency of the array to avoid aliasing when computing DOAs from this calibration data. Numerical evaluations show the validity of our geometric aliasing model.

Track E – Array Signal Processing

Session: MPb6 – Wireless Localization

Chair: ***Petar M. Djuric,*** *Stony Brook University*

MP6b-1 3:30 PM

Direct Localization of Emitters Using Widely Spaced Sensors in Multipath Environments

Nil Garcia, New Jersey Institute of Technology, United States; Marco Lops, Universita degli Studi di Cassino, Italy; Martial Coulon, University of Toulouse, France; Alexander Haimovich, New Jersey Institute of Technology, United States; Jason Dabin, Space and Naval Warfare Systems Command - Systems Center Pacific, United States

The problem of localizing multiple emitters using widely spaced sensors is commonly solved by estimating parameters such as time-of-arrivals. Techniques in which sensors estimate intermediate parameters independently are suboptimal relative to direct localization, where emitter locations are estimated jointly. We propose a direct localization method for frequency-selective channels for known transmitted signals. The proposed method exploits the sparsity of the emitters as well as differences in the properties of line of sight versus multipath components of signals received at the sensors. It is shown that the proposed method has superior accuracy and is robust to sensors with blocked line-of-sight.

MP6b-2 3:55 PM

Millimeter-Wave Personal Radars for 3D Environment Mapping

Anna Guerra, Francesco Guidi, Davide Dardari, University of Bologna, Italy

The future availability of millimeter-wave technology in next generation smartphones will allow the exploitation of compact massive antenna arrays thus enabling new interesting applications such as those related to the personal radar concept. In this paper we analyze the possibility of accurate environment mapping through millimeter-wave personal radars. The impact on map reconstruction accuracy of signal bandwidth, number of antennas, and non-idealities is investigated.

MP6b-3 4:20 PM

Simultaneous Tracking and RSS Model Calibration by Robust Filtering

Juan Manuel Castro-Arvizu, Universitat Politècnica de Catalunya, Spain; Jordi Vilà-Valls, Pau Closas, Centre Tecnològic de Telecomunicacions de Catalunya, Spain; Juan Fernández-Rubio, Universitat Politècnica de Catalunya, Spain

Received Signal Strength (RSS) localization is widely used due to its simplicity and availability in most mobile devices. The RSS channel model is defined by the propagation losses and the shadow fading. These parameters might vary over time because of changes in the environment. In this paper, the problem of tracking a mobile node by RSS measurements is addressed, while simultaneously estimating a two-slope RSS model. The methodology considers a Kalman filter with Interacting Multiple Model architecture, coupled to an on-line estimation of the observation's variance. The performance of the method is shown through numerical simulations in realistic scenarios.

MP6b-4 4:45 PM

Proximity Detection with RFID in the Internet of Things

Miodrag Bolic, Majed Rostamian, University of Ottawa, United States; Petar Djuric, Stony Brook University, United States

In the "Internet of Things" (IoT), the things will be able to sense, communicate, and interact. They will also exchange data, information and knowledge, and locate themselves and other things that surround them. In order to be able to interact, the things need to recognize that they are in proximity of other things. It is anticipated that the most widespread components of the IoT will be passive radio frequency identification (RFID) tags because they are inexpensive and provide automatic identification. However, passive RFID tags are not seen as capable of performing complex operations, such as proximity detection and localization, which will be required in future networks. In this paper, we describe existing problems with current RFID systems and survey potential solutions for proximity detection. Then we present a new RFID device called "Sense-a-Tag" (ST) that can passively detect and decode backscatter signals from tags in its proximity. We show that when STs are added to a standard RFID system, the problems of proximity detection and localization in the IoT with RFID tags can readily be resolved. We demonstrate the feasibility of an ST-based RFID system by experiments of proximity detection.

Track G – Architecture and Implementation

Session: MPa7 – Resource-aware and Domain-specific Computing

Chair: ***Frank Hannig,*** *Friedrich-Alexander University Erlangen-Nurnberg*

MP7a-1 1:30 PM

Partial Expansion of Dataflow Graphs for Resource-Aware Scheduling of Multicore Signal Processing Systems

George Zaki, IGI Technologies, United States; William Plishker, Shuvra Bhattacharyya, University of Maryland, College Park, United States; Frank Fruth, Texas Instruments, United States

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.

MP7a-2 1:55 PM

Performance Analysis of Weakly-Consistent Scenario-Aware Dataflow Graphs

Marc Geilen, TU Eindhoven, Netherlands; Joachim Falk, University of Erlangen-Nuremberg, Germany; Christian Haubelt, Universität Rostock, Germany; Twan Basten, TU Eindhoven, Netherlands; Bart Theelen, TNO-ESI, Netherlands; Sander Stuijk, TU Eindhoven, Netherlands

The timed dataflow model of computation is a useful performance analysis tool for Electronic System Level Design automation and embedded software synthesis. It is used to model systems, including platform mapping and resource scheduling, of components communicating and synchronizing in regular patterns. Its determinism gives it strong analysability properties and makes it less subject to state-space explosion problems. Because of its monotonic temporal behaviour it can provide hard real-time guarantees on throughput and latency. It is expressive enough to cover a fairly large class of applications and platforms. The trend however, in both embedded applications and their platforms is to become more dynamic, reaching the limits of what the model can express and analyse with tight performance guarantees. Scenario-aware dataflow (SADF) is an extension that allows more dynamism to be expressed, introducing a controlled amount of non-determinism into the model to represent different scenarios of behaviour. The combination of a relatively infrequent switching between scenarios and still deterministic dataflow behaviour within scenarios stretches the expressiveness of the model while keeping sufficient analysability. In this report we investigate so-called weakly consistent graphs in which the scenario changes are not tightly coupled with periods of repetitive behaviour of the static dataflow behaviour in scenarios as in previous methods. We define their semantics in terms of (max,+) algebra and we introduce a method to analyse throughput using a generalisation of (max,+)-automata.

MP7a-3 2:20 PM

Application-driven Reconfiguration of Shared Resources for Timing Predictability of MPSoC Platforms

Deepak Gangadharan, Ericles Sousa, Vahid Lari, Frank Hannig, Juergen Teich, University of Erlangen-Nuremberg, Germany

The growing demand of compute-intensive applications has resulted in the widespread acceptance of heterogeneous MPSoC platforms. The primary reason for this trend is due to the better performance and power efficiency exhibited by the heterogeneous architectures consisting of standard processor cores and hardware accelerators. However, multiple processors accessing shared resources such as cache, memory, and bus leads to significant contention on them, thereby decreasing the performance. Moreover, the effect of shared resource contention worsens in the presence of multiple application scenarios having different execution requirements. To mitigate this problem, we first propose an application-driven runtime reconfiguration approach for shared resources to adapt to the varying execution requirements. We also present a performance analysis framework to take the reconfiguration into consideration while providing timing guarantees for the applications. The results from the analytical framework are then validated using experimental evaluation for different algorithms from the video processing domain.

MP7a-4 2:45 PM

Accelerating the Dynamic Time Warping Distance Measure using Logarithmic Arithmetic

Joseph Tarango, University of California, Riverside / Intel, United States; Eamonn Keogh, Philip Brisk, University of California, Riverside, United States

We are designing an application-specific processor that has been customized for the dynamic time warping (DTW) application, a widely used similarity measure in time-series data mining. Most DTW reference software is floating-point, and previous hardware implementations either use floating-point or fixed-point binary arithmetic. In this paper, we will evaluate the possibility to implement DTW using a logarithmic number system (LNS). We will rewrite portions of the algorithm to make them more amenable to LNS arithmetic, and we will design customized arithmetic operations and instruction set extensions that employ LNS. We believe that this will enable a cheaper and more efficient implementation of the algorithm in comparison with known state-of-the-art techniques.

Track C – Networks

Session: MPb7 – Detection and Estimation for Networked Data

Chair: ***Yue Lu,*** *Harvard University*

MP7b-1 3:30 PM

Detecting Convoys in Networks of Short-Range Sensors

Sean Lawlor, Michael Rabbat, McGill University, Canada

We consider the problem of detecting groups of vehicles that are traveling together as a convoy. License plate recognition sensors are an emerging technology which can be used to solve this problem. The sensors are deployed throughout road networks across the world and meta-data about the vehicles passing in front of each sensor is collected. These provide discrete, irregularly sampled, time series information about where vehicles are traveling. This paper proposes a method to solve the problem of detecting convoys utilizing irregularly sampled time series information about objects moving between sensors.

MP7b-2 3:55 PM

Distributed SPRT for Gaussian Binary Hypothesis Testing: Performance Analysis and Fundamental Trade-offs

Anit Sahu, Soummya Kar, Carnegie Mellon University, United States

This paper studies the problem of sequential Gaussian binary hypothesis testing in a distributed multi-agent network. A distributed sequential probability ratio test (SPRT) type algorithm of the consensus-plus-innovations form is proposed, in which the agents update their decision statistics by simultaneously processing local observations (innovations) sensed sequentially over time and information obtained from neighboring agents (consensus). Local detection thresholds achieving pre-specified type I and type II error probabilities are derived and large deviation exponents for the stopping time distributions are obtained.

MP7b-3 4:20 PM

Denoising of Network Graphs using Topology Diffusion

Mohammad Aghagolzadeh, Hayder Radha, Michigan State University, United States

PDE based diffusion has been utilized for image denoising for more than two decades. It is known that the process of diffusion preserves the edges and object boundaries making it a suitable preprocessing for edge detection. Synergetic to these efforts, in this work, we apply diffusion to network graphs leading to an efficient algorithm for removing anomalous structures from the network topology. The driving force for the diffusion process in our work is the clustering propensity that exists in real social networks. The proposed diffusion enhances the boundaries of communities which makes it a suitable step prior to community detection.

MP7b-4 4:45 PM

Optimal Hypothesis Testing with Combinatorial Structure: Applications in Graph Detection

Yue M. Lu, Harvard University, United States

We consider hypothesis testing with combinatorial structure: the alternate and null hypotheses differ in an unknown subset of the variables. For example, given Gaussian measurements on the nodes of a graph, we test whether one out of a collection of possible subgraphs has elevated mean; or, in a time series of such measurements, whether there is a walk on graph with elevated mean. We provide in many cases sharp bounds for generalized error exponents describing the error decay rate. We illustrate a phase transition in the performance and show that if the SNR scales appropriately, genie-aided performance is achievable.

Session: MPa8 – Network Resource Allocation and Localization 1:30 PM–3:10 PM

Chair: ***Michael Rabbat,*** *McGill University*

MP8a1-1

Optimal Scheduling Policies and the Performance of the CDF Scheduling

PhuongBang Nguyen, Bhaskar Rao, University of California, San Diego, United States

We seek to characterize the performance properties of scheduling policies for wireless systems that are based on Cumulative Density Functions (CDF) of the channels. We first derive optimal scheduling policies for a two-user system under max-sum rate and max-min rate performance criteria subject to the same temporal resource constraints as those under CDF-based policies. The behaviors of the CDF schemes are then compared against those of the optimal policies. We illustrate the differences in scheduling decision boundaries as well as the sub-optimality in rate performance of the CDF-based policies.

MP8a1-2

Joint Interference and User Association Optimization in Cellular Wireless Networks

Changkyu Kim, Russell Ford, Sundeep Rangan, New York University, Polytechnic School of Engineering, United States

In cellular wireless networks, user association refers to the problem of assigning mobile users to base station cells. This paper considers a general class of utility maximization problems for joint optimization of mobile user associations and bandwidth and power allocations. The formulation can incorporate a large class of network topologies, interference models, SNR-to-rate mappings and network constraints. While the problem is nonconvex, our main contribution shows that the optimization admits a separable dual decomposition. This property enables fast computation of upper bounds on the utility as well as an efficient, distributed implementation for approximate local optimization via augmented Lagrangian techniques.

MP8a1-3

Throughput Maximization in Wireless Powered Communication Networks with Energy Saving

Rui Wang, Donald Brown, Worcester Polytechnic Institute, United States

This paper considers optimal time and energy allocation to maximize the sum throughput of a wireless powered communication networks for the case when the nodes can save energy for later time blocks in a time division multiple access scenario with where a wireless access point transmits to a group of users which harvest the energy and then use this energy to transmit back to the access point. To maximize the sum-throughput over L blocks, the initial optimization problem is separated into two sub-problems, which can be solved efficiently.

MP8a1-4

Optimal Flow Bifurcation in Networks with Dual Base Station Connectivity and Non-ideal Backhaul

Amitav Mukherjee, Hitachi America, Ltd., United States

In the dual connectivity architecture in LTE-Advanced systems, a user with multiple transceivers can be simultaneously connected to two eNBs that operate independently at the radio layer. One of them is designated as a master eNB (MeNB) which can choose to forward a portion of the UE traffic to the secondary eNB (SeNB) over a non-ideal backhaul link, and serve the remaining data by itself. We examine how to optimally bifurcate the traffic flow when the MeNB has only statistical information of the SeNB channel state information. A fluid model approximation is used to derive individual and global myopic policies.

MP8a1-5

Joint Sequential Target State Estimation and Clock Synchronization in Wireless Sensor Networks

Jichuan Li, Arye Nehorai, Washington University in St. Louis, United States

Clock Synchronization is crucial to a wireless sensor network but often difficult to maintain. In this paper, we propose a joint estimation method to estimate both target states and clock synchronization status based on sensor observations from a wireless sensor network. We build a multi-sensor state-space model to connect clock synchronization status with sequential target state transition. We divide the joint estimation problem into state and parameter estimation problems that alternate to update their

own estimates via the expectation-maximization algorithm. We use the Monte Carlo method in the state estimation to handle nonlinear functions and non-Gaussian noise, and stochastic approximation in the EM algorithm to compensate for Monte Carlo approximation error. Numerical examples demonstrate that the proposed joint estimation method yields lower estimation error than a target estimation method.

MP8a1-6
High-Accuracy Vehicle Position Estimation Using a Cooperative Algorithm with Anchors and Probe Vehicles

Ramez L. Gerges, First Responder System Testbed (FiRST), United States; John J. Shynk, University of California, Santa Barbara, United States

This paper describes a method for achieving lane differentiation without requiring expensive GNSS receivers in every vehicle. Lane identification on a highway can be used to optimize transportation network safety, by improving a vehicle's ability to avoid collision and to safely complete lane-change maneuvers. Using a cooperative technique, a vehicle communicates with road infrastructure and nearby connected vehicles to achieve sub-meter lane identification. We assume that a small subset of vehicles have high-accuracy GPS localization, which we refer to as probe vehicles. Other vehicles use location information from the probe vehicles and fixed infrastructure landmarks to improve their position estimates.

MP8a1-7
Statistical Scheduling of Economic Dispatch and Energy Reserves of Hybrid Power Systems with High Renewable Energy Penetration

Yi Gu, Huaiguang Jiang, University of Denver, United States; Yingchen Zhang, National Renewable Energy Laboratory, United States; David Wenzhong Gao, University of Denver, United States

A statistical scheduling approach to economic dispatch and energy reserves is proposed in this paper. The proposed approach focuses on minimizing the overall power production cost with considerations of renewable energy uncertainty, transmission cost, and power system security. For our comprehensive numerical study, the proposed approach will be simulated and studied in the IEEE 24-bus reliability test system (IEEE-RTS), which is the commonly used for evaluating power system stability and reliability.

Track F – Biomedical Signal and Image Processing
Session: MPa8 – Bioinformatics and Medical Imaging 1:30 PM–3:10 PM

Chair: ***George Atia,*** *University of Central Florida*

MP8a2-1
Comparison and Integration of Genomic Profiles Predict Brain Cancer Survival and Drug Targets

Katherine Aiello, Orly Alter, University of Utah, United States

Recently, we demonstrated the effectiveness of the generalized singular value decomposition (GSVD) in comparing patient-matched genomic profiles and identifying a pattern of DNA copy-number aberrations that correlates with glioblastoma survival. Here, we show cross-platform validation of this signature, bringing it a step closer to the clinic. Surprisingly, we also find that the prognostic value of the signature is maintained for lower-grade astrocytomas (LGAs). GSVD of LGA patient-matched profiles uncovers molecular similarities and differences between glioblastoma and LGA that suggest drug targets.

MP8a2-2
Tensor GSVD for Comparison of Two Large-Scale Multidimensional Datasets

Theodore Schomay, Preethi Sankaranarayanan, Katherine Aiello, Orly Alter, University of Utah, United States

There exists a fundamental need for frameworks that can simultaneously compare and contrast large-scale data tensors, e.g., biomedical datasets recording multiple aspects of a disease across a set of patients. We describe a novel exact and unique simultaneous decomposition for two tensors that generalizes the GSVD to a tensor GSVD (tGSVD). In an application to biomedical datasets, we show that tGSVD comparisons of two ovarian cancer patient- and platform-matched genomic datasets from The Cancer Genome Atlas predict survival and drug targets.

MP8a2-3

An Efficient ADMM-based Sparse Reconstruction Strategy for Multi-Level Sampled MRI

Joshua Trzasko, Eric Borisch, Paul Weavers, Armando Manduca, Phillip Young, Stephen Riederer, Mayo Clinic, United States

Sparsity-driven image reconstruction is a promising paradigm for improving the spatial, temporal, and contrast resolution in magnetic resonance imaging (MRI). However, high computational ex-pense continues to inhibit the translation of these techniques into routine clinical practice. In many MRI acquisition protocols (e.g., time-resolved CAPR), the sampling operator can be factored into a uniform and non-uniform component. In this work, we present a novel alternating direction method-of-multipliers (ADMM) strategy for sparse Cartesian SENSE-type MRI reconstruction that explicitly targets such multi-level sampling protocols, and demonstrate that this framework ena-bles 3D contrast-enhanced MR angiogram (CE-MRA) sparse reconstruction in only seconds.

MP8a2-4

Multiscale Functional Networks in Human Resting State Functional MRI

Jacob Billings, Emory University, United States; Alessio Medda, Georgia Tech Research Institute, United States; Shella Keilholz, Georgia Institute of Technology / Emory University, United States

Recent advent of fast imaging techniques for MRI application allow whole brain coverage with sub-second resolution, opening the door for new data-driven computational techniques that can harvest the information contained in the data. To this end, we examine the use of wavelet based spectral decomposition and hierarchical clustering for resting state functional MRI analysis. Wavelet packets naturally enable short time spectral decomposition with minimal temporal window lengths across multiple frequency ranges, while hierarchical clustering is used for organizing broadband and filtered fMRI data into functional network. This method was applied to human group data from 5 volunteers from the 1000 Functional Connectomes database. Preliminary results show that this technique can produce spatially distinct networks on multiple scales

MP8a2-5

Piecewise Linear Slope Estimation

Atul Ingle, William Sethares, Tomy Varghese, James Bucklew, University of Wisconsin-Madison, United States

This paper presents a method for directly estimating slope values in a noisy piecewise linear function. By imposing a Markov structure on the sequence of slopes, piecewise linear fitting is posed as maximum a posteriori estimation problem. A dynamic program efficiently solves this by traversing a linearly growing trellis. A pseudo-EM algorithm to estimate model parameters from data is proposed and its convergence behavior is analyzed. Ultrasound shear wave imaging is presented as the primary application. The algorithm is general enough for applicability in other fields, as suggested by another application to estimation of shifts in financial interest rate data.

MP8a2-6

Fast Magnetic Resonance Parametric Imaging via Model-Based Low-Rank Matrix Factorization

Parisa Amiri Eliasi, New York University, Polytechnic School of Engineering, United States; Li Feng, Ricardo Otazo, New York University, School of Medicine, United States; Sundeep Rangan, New York University, Polytechnic School of Engineering, United States

Magnetic Resonance Parametric Imaging is a recently-proposed method that permits quantitative determination of MR parameters such as the T1 and T2 relaxation times. In contrast to conventional MRI, one or more encoding parameters in the RF excitation are randomly varied over the scan and tissue parameters are inferred from the temporal response to the excitation. This work presents a novel low-rank model-based matrix-factorization method for joint reconstruction and parameter estimation suitable for highly accelerated (i.e. highly undersampled) scans. The method is demonstrated on T2 cardiac breath-hold imaging with varying spin echo times.

MP8a2-7

A Signal Model for Forensic DNA Mixtures

Ullrich Mönich, Massachusetts Institute of Technology, United States; Catherine Grgicak, Boston University, United States; Viveck Cadambe, Yonglin Wu, Massachusetts Institute of Technology, United States; Genevieve Wellner, Boston University, United States; Ken Duffy, National University of Ireland Maynooth, Ireland; Muriel Médard, Massachusetts Institute of Technology, United States

For forensic purposes, short tandem repeat allele signals are used as DNA fingerprints. The interpretation of signals measured from samples has traditionally been conducted by thresholding. More quantitative approaches have recently been developed, but not for the purposes of identifying an appropriate signal model. By analyzing data from 643 single person samples, we develop such a signal model. Our analysis suggests that additive noise is best modeled via log-normal distributions and that variability in peak heights is well described as Gaussian. This is a crucial step towards the development of principled techniques for mixed sample signal deconvolution.

Track E – Array Signal Processing

Session: MPa8 – Source Separation and Array Processing 1:30 PM–3:10 PM

Chair: ***Douglas Cochran,*** *Arizona State University*

MP8a3-1

Forward - Backward Greedy Algorithms for Signal Demixing

Nikhil Rao, Parikshit Shah, Stephen Wright, University of Wisconsin, United States

In many signal processing applications, one wishes to separate mixtures of signals. Common among these are the separation of sparse and low rank components in image and video processing, sparse and group sparse models in multitask learning and spikes and sinusoids in source separation problems. An underlying theme for performing such recovery is the notion of ``simplicity” of the components with respect to a given basis or frame. For specific problems of interest, many methods exist to perform recovery, but an approach that generalizes to arbitrary notions of simplicity has not been forthcoming. In this paper, we propose a framework for signal demixing when the components are defined to be simple in a fairly arbitrary manner. Despite being very general, our method remains computationally simple and can be used in a variety of practical applications.

MP8a3-2

An Extended Family of Bounded Component Analysis Algorithms

Huseyin Atahan Inan, Alper Tunga Erdogan, Koc University, Turkey

Bounded Component Analysis (BCA) is a recent concept proposed as an alternative method for Blind Source Separation problem. BCA enables the separation of dependent as well as independent sources from their mixtures under the practical assumption on source boundedness. This article extends the optimization setting of a recent BCA approach which can be used to produce a variety of BCA algorithms. The article also provides examples of objective functions and the corresponding iterative algorithms. The numerical examples illustrate the advantages of proposed BCA examples regarding the correlated source separation capability over the state of the art ICA based approaches.

MP8a3-3

Source Separation in Noisy and Reverberant Environment using Miniature Microphone Array

Shuo Li, Milutin Stanacevic, Stony Brook University, United States

In the unique framework that combines spatial sensing and independent component analysis, we recover the impinging acoustic sources and estimate their direction of arrival on the miniature four microphone array. We examine and quantify the performance of the proposed algorithm under different acquisition noise and reverberant conditions. With artificially generated microphone signals using room acoustic model, the algorithm demonstrates over 10 dB separation in moderate reverberant environments. With the recordings from a miniature microphone array in a typical conference-room environment, the algorithm demonstrates over 10 dB separation performance if the angular distance between two speech sources is over 30 degrees.

MP8a3-4
Competitive Algorithm Blending for Enhanced Source Separation
Keith Gilbert, Karen Payton, University of Massachusetts Dartmouth, United States

This paper studies the performance of competitive blending of outputs of multiple source separation algorithms running in parallel. The proposed blending system can operate in three modes; two that can incorporate prior information to control a source separtion network or influence blending, and a third that operates in a fully blind mode. Although derivation of the blending methods is given within the context of the instantaneous case, extension to the convolutive case is given. Results of example applications show that the blending methods can produce an better overall set of source estimates than any constituent algorithm.

MP8a3-5
Design of Coprime DFT Arrays and Filter Banks
Chun-Lin Liu, P. P. Vaidyanathan, California Institute of Technology, United States

Coprime arrays in array processing offer an enhanced degree of freedom of O(MN) given M+N sensors, where M and N are coprime and are associated with the interelement spacing and the number of sensors. Direction-of-arrival estimation and beamforming are popular applications of coprime arrays. The performance in some of these applications is based on coprime DFT filter banks (coprime DFTFBs), which cascade an M-channel DFTFB and an N-channel DFTFB to achieve equivalently MN-channel filter banks. However, the practical design of coprime DFTFBs, which is important in applications of coprime arrays, has not been well-studied. In this paper, the practical design for coprime DFTFBs is related to interpolated FIR (IFIR) filter designs. Based on M, N, filter orders, and peak ripples, a systematic design procedure is proposed. Our design leads to an additional parameter □ that controls tradeoffs between the bandwidths of passbands and stopbands. Different approximations for transition bands are considered to estimate □. A design example for different □ is also presented.

MP8a3-6
The Differential Geometry of Asymptotically Efficient Subspace Estimation
Thomas Palka, Raytheon, United States; Richard Vaccaro, University of Rhode Island, United States

Subspace estimation is often a prelude to parameter estimation. The underlying parameterization constrains the set of subspaces of interest and the singular value decomposition, which is the maximum likelihood (ML) estimator when rank is the only limitation, is not the ML subspace estimator for the parameter constrained problem. Using the Stiefel manifold formulation of the standard problem we establish intrinsic Cramer-Rao bounds for the constrained subspace estimation problem. In addition we establish an asymptotic ML formulation for the constrained problem which has a closed-form solution for the important special case of harmonic signals on uniformly spaced sensor arrays.

MP8a3-7
Effects of Network Topology on the Conditional Distributions of Surrogated Generalized Coherence Estimates
Lauren Crider, Douglas Cochran, Arizona State University, United States

The generalized coherence estimate has an established history as a test statistic in multiple-channel signal detection. Recent work has considered the use of maximum-entropy matrix completion when elements are missing from the gram matrix from which the generalized coherence estimate is computed. This is desirable in sensor network settings, for example, where direct communication is not available between every pair of nodes in the network. This paper examines the role of network topology in determining the conditional distributions of the statistic obtained by the matrix completion process under both signal-present and signal-absent hypotheses.

MP8a3-8
Maximum Energy Sequential Matrix Diagonalisation for Parahermitian Matrices
Jamie Corr, Keith Thompson, Stephan Weiss, University of Strathclyde, United Kingdom; John McWhirter, Cardiff University, United Kingdom; Ian Proudler, Loughbourgh University, United Kingdom

Sequential matrix diagonalisation (SMD) refer to a family of algorithms to iteratively approximate a polynomial matrix eigenvalue decomposition. Key is to transfer as much energy as possible from off-diagonal elements to the diagonal per iteration, which has led to fast converging SMD versions involving judicious shifts within the polynomial matrix. Through an exhaustive search, this paper determines the optimum shift in terms of energy transfer. Although costly to implement, this scheme yields an important benchmark to which limited search strategies can be compared. In simulations, multiple-shift SMD algorithms can perform within 10% of the optimum energy transfer per iteration step.

Track G – Architecture and Implementation

Session: MPa8 – Digital Communications 1:30 PM–3:10 PM

Chair: ***James Glenn-Anderson,*** *Supercomputer Systems Inc.*

MP8a4-1
High-throughput DOCSIS Upstream QC-LDPC Decoder

Bei Yin, Michael Wu, Rice University, United States; Christopher Dick, Xilinx Incorporated, United States; Joseph R. Cavallaro, Rice University, United States

In this paper, we propose a new scheduling scheme that can significantly improve the decoding throughput of the layered min-sum LDPC (Low Density Parity Check) decoder for the high-throughput data over cable service interface specification (DOCSIS) standard. The new scheduling scheme reduces the data dependency in the LDPC decoder by rescheduling the two-step min calculation. The scheme also avoids the data conflict in the decoder. We then implement the decoder using fully parallel architecture on Xilinx FPGA with high level synthesis tool. The resulting design can achieve 1.25\,Gbps throughput with 204.8\,MHz clock frequency and only 25\% device usage.

MP8a4-2
On the Performance of LDPC and Turbo Decoder Architectures with Unreliable Memories

Joao Andrade, Instituto de Telecomunicações, Universidade de Coimbra, Portugal; Aida Vosoughi, Guohui Wang, Rice University, United States; Georgios Karakonstantis, Andreas Burg, Telecommunication Circuits Lab, EPFL, Switzerland; Gabriel Falcao, Vitor Silva, Instituto de Telecomunicações, Universidade de Coimbra, Portugal; Joseph R. Cavallaro, Rice University, United States

In this paper, we investigate and compare the impact of faulty bit-cells on the performance of a Turbo and LDPC channel decoder based on realistic memory failure models. Our study determines the upper-bounds on the number of bit-cell faults in the different memory modules and iterations that can be tolerated by the inherent error resilience of such codes. We also show how selective protection of some bits in the various memory modules at specific decoding iterations can improve the error resilience under high fault rates.

MP8a4-3
Successive Cancellation List Polar Decoder using Log-likelihood Ratios

Bo Yuan, Keshab K. Parhi, University of Minnesota, Twin Cities, United States

Successive cancellation list (SCL) decoding algorithm is a powerful method that can help polar codes achieve excellent error-correcting performance. However, the current SCL algorithm and decoders are based on likelihood or log-likelihood forms, which render high hardware complexity. In this paper, we propose a log-likelihood-ratio (LLR)-based SCL (LLR-SCL) decoding algorithm, which only needs half the computation and storage complexity than the conventional one. Then, based on the proposed algorithm, we develop low-complexity VLSI architectures for LLR-SCL decoders. Analysis results show that the proposed LLR-SCL decoder achieves 50% reduction in hardware and 98% improvement in hardware efficiency, respectively.

MP8a4-4
60 GHz Synthetic Aperture Radar for Short-Range Imaging: Theory and Experiments

Babak Mamandipoor, University of California, Santa Barbara, United States; Greg Malysa, Amin Arbabian, Stanford University, United States; Upamanyu Madhow, University of California, Santa Barbara, United States; Karam Noujeim, Anritsu Co., United States

We report on preliminary experimental results, and associated theory, for a 60 GHz synthetic aperture radar (SAR) testbed for short-range (sub-meter) imaging. Our testbed consists of a monostatic radar with synchronized transmitter and receiver, with lateral motion (over 10-30 cm) providing the SAR geometry, and range resolution provided by stepped frequency continuous wave (SFCW) signals covering a band exceeding 6 GHz. Centimeter (cm) level resolution is achieved in both cross-range and slant-range. Computation of the Cramer-Rao Lower Bound (CRLB) and normalized cross-correlation between responses to close-by scatterers show how the crossrange resolution is indeed limited by the SAR geometry.

MP8a4-5

A Systematic Procedure for Deriving Block-Parallel, Power Efficient, Digital Filter Architectures for High- Speed Data Conversion

Paraskevas Argyropoulos, Hanoch Lev-Ari, Northeastern University, United States

A systematic and highly intuitive procedure for deriving the digital filter realization of an arbitrary block-parallel and/or pipelined discrete-time transfer function is proposed. The method is based on simple block diagram and multi-rate properties and is intended for low-power processing by reducing (a) the required system clock frequency and (b) the number of required multipliers by facilitating arithmetic resource sharing. Several detailed design examples are provided. The technique and examples presented are intended to serve as a high-speed filter realization reference for Digital and DSP ASIC developers.

MP8a4-6

Distributed Synchronization of a Testbed Network with USRP N200 Radio Boards

Gilberto Berardinelli, Jakob L. Buthler, Fernando M. L. Tavares, Oscar Tonelli, Dereje A. Wassie, Farhood Hakhamaneshi, Troels B. Sørensen, Preben Mogensen, Aalborg University, Denmark

In this paper, we evaluate the feasibility of a distributed synchronization technique in a testbed network based on Universal Software Radio Peripheral N200 (USRP N200) hardware boards. We consider a setup with 8 neighbor nodes, and different deployment conditions (open space with line-of-sight and nodes located in different office rooms). Measurements collected on a testbed server demonstrate the capability of our technique of aligning the timing of the nodes with a precision of few μs.

MP8a4-7

Design Study of a Short-Range Airborne UAV Radar for Human Monitoring

Sevgi Zubeyde Gurbuz, TOBB University of Economics and Technology, Turkey; Muhsin Alperen Bolucek, Tunahan Kirilmaz, TUALCOM Communication and RF Technologies, Turkey; Unver Kaynak, TOBB University of Economics and Technology, Turkey

UAVs have many attributes making them advantageous in many surveillance applications, such the control of borders against illegal trafficking. An important task in border control is to monitor the activities of any people in the region. In particular, discrimination between friendly and non-cooperative targets is of high importance. This work studies the top-level design and tradeoffs involved in the development of a short-range UAV for human monitoring, such as type of UAV, power and weight requirements, frequency and type of radar, and signal processing algorithms. Additionally, the compatibility of the TAN100 UAV for a human monitoring mission is evaluated.

MP8a4-8

Max-Min Fairness in Compact MU-MIMO Systems: Can the Matching Network Play a Role?

Yahia Hassan, Armin Wittneben, ETH Zurich, Switzerland

We consider a MU-MIMO system with compact antenna array at the receiver that uses successive interference cancellation. Such a system is characterized by spatial correlation, antenna coupling and noise correlation. For the two cases of time sharing and no time sharing we design the matching network to alter the capacity region in order to maximize the minimum user rate. Our results show substantial performance enhancement in comparison to the conventional matching network that ignores coupling and the one maximizing the sum rate. We view our results as a step in connecting the two worlds of information theory and circuit theory.

Track H – Speech, Image and Video Processing

Session: MPa8 – Image and Speech Processing 1:30 PM–3:10 PM

Chair: ***Linda S. DeBrunner,*** *Florida State University*

MP8a5-1

Acoustic Echo and Noise Cancellation using Kalman Filter in a Modified GSC Framework

Subhash Tanan, Karan Nathwani, Ayush Jain, Rajesh M Hegde, Indian Institute of Technology Kanpur, India; Ruchi Rani, Abhijit Tripathy, Samsung R&D Institute India Delhi, India

In this paper a novel method for acoustic echo and noise cancellation in a generalized sidelobe canceler framework (GSC) is described. The primary contribution of this work is the development of multichannel adaptive Kalman filter (MCAKF) in a modified GSC framework. Additionally both the near end speech signal and noise is assumed to be unknown in this work.

In contrast to conventional GSC, the MCAKF developed in this context is used to estimate the noise and residual echo. The performance of proposed method in terms of both perceptual evaluation and distant speech recognition on the ARCTIC database is motivating.

MP8a5-2

Paper Texture Classification via Multi-Scale Restricted Boltzman Machines

Arash Sangari, William Sethares, University of Wisconsin-Madison, United States

The performance of two Restricted Boltzman Machine (RBM) algorithms are compared in the paper texture classification application when utilizing a multi-scale Local Binary Pattern sampling method. In the first approach, a separate RBM is trained for each texture-type to estimate the probability distribution. In the second approach, a Deep Belief Net, which consists of a cascade of RBM layers, is used to extract texture features which are then input into a logistic regression layer. The classification performance of the two methods are compared in detail.

MP8a5-3

Regularized Logistic Regression Based classification for Infrared Images

Golrokh Mirzaei, Mohsin M. Jamali, University of Toledo, United States; Jeremy Ross, Peter Gorsevski, Verner Bingman, Bowling Green State University, United States

There is an increase in bird and bat mortality near wind farms. It is desirable to document and quantify behavior and activity of birds/bats near wind farms. Infrared Imaging is a useful monitoring method. However, IR images do not provide information as whether it is a bird, bat or insect. A logistic regression classifier is used to provide category information of targets. There are no priori known database of images available for birds, and bats. We have extracted and used the features of targets for classification purposes. A database of labeled category based on the features has been created.

MP8a5-4

Localizing Near and Far Field Acoustic Sources with Distributed Microphone Arrays

Martin Weiss Hansen, Jesper Rindom Jensen, Mads Græsbøll Christensen, Aalborg University, Denmark

In this paper, we consider acoustic source localization using distributed microphone arrays. TDOAs are estimated using a recently proposed method based on joint DOA and range estimation. The TDOAs are used to estimate the location of an acoustic source using a recently proposed method, based on a 4D parameter space. The performance of the proposed method for acoustic source localization is compared to GCC-PHAT, and a method based on joint DOA and pitch estimation. Results show a decrease in the error of the estimated position when joint DOA and range estimation is used for TDOA estimation.

MP8a5-5

Graph Wavelet Transform: Application to Image Segmentation

Alp Ozdemir, Selin Aviyente, Michigan State University, United States

Recently, there has been a lot of work on extending traditional signal processing methods to irregular domains such as graphs. Graph wavelet transform offers a multiscale analysis of graphs similar to traditional wavelets. Similar to wavelets which are effective at detecting transients in a signal, graph wavelets can be used to detect discontinuities of functions defined on graphs. In this paper, we use this realization to propose a graph wavelet based approach to image segmentation. The images are first transformed to the graph domain and the graph wavelet transform is used to detect the discontinuities in the pixel domain.

MP8a5-6

Histogram Transform Model Using MFCC Features for Text-Independent Speaker Identification

Hong Yu, Zhanyu Ma, Beijing University of Posts and Telecommunications, China; Minyue Li, Jun Guo, Google, Inc., Sweden

A novel text-independent speaker identification method is proposed in this paper. This method uses the MFCCs and the dynamic information among adjacent frames as feature set to capture the speaker's characteristics. The PDF of these super MFCCs features is estimated by the recently proposed histogram transform (HT) method, which generated more train data in a randomly transform way to realize the histogram PDF estimation and receded the discontinuity problem of the common multivariate histograms computing. Compared to the conventional PDF estimation method, such as Gaussian mixture model, the HT model shows promising improvement in a SI task.

Track E – Array Signal Processing

Session: TAa1 – High Dimensional and Large Volume Data

Chair: ***Sergiy Vorobyov,*** *Aalto University*

TA1a-1 8:15 AM

Tensor Restricted Isomety Property for Multilinear Sparse System of Genomic Interactions

Alexandra Fry, Carmeliza Navasca, University of Alabama at Birmingham, United States

We model multilinear genomic interactions through a sparse tensor equation. We show that a tensor restricted isometry property is necessary to find the sparse unique solution in the multilinear system. This solution will drastically reduce the number of experiments needed to assess which genes and combinations of genes are necessary for viral replication. In addition, we also look at a novel numerical method for approximating the sparse unique solution.

TA1a-2 8:40 AM

Analysis of a Separable STAP Algorithm for Very Large Arrays

Jie Chen, Feng Jiang, A. Lee Swindlehurst, University of California, Irvine, United States

Studies of massive MIMO in wireless communications have recently attracted significant attention. The benefits of very large arrays can also be exploited in space-time adaptive processing (STAP). In this paper, we analyze the performance of a reduced-dimension separable STAP algorithm. We study the performance of it for clairvoyant interference covariance matrices with orthogonality assumptions on the steering vectors, and show that in the asymptotic sense this simplified scheme performs as well as the fully adaptive STAP method. Appealing to random matrix theory, we finally do an analysis for the case that the covariance matrix is estimated using secondary data.

TA1a-3 9:05 AM

Spatial-Temporal Characterization of Synchrophasor Measurement Systems - A Big Data Approach for Smart Grid System Situational Awareness

Huaiguang Jiang, University of Denver, United States; Lei Huang, Electric Power Research Institute, China Southern Power Grid, China; Jun Zhang, University of Denver, United States; Yingchen Zhang, National Renewable Energy Laboratory, United States; David Wenzhong Gao, University of Denver, United States

An approach for fully characterizing a synchrophasor measurement system is proposed in this paper, which aims to provide substantial data volume reduction while keep comprehensive information from synchrophasor measurements in time and spatial domains. Specifically, the optimal synchrophasor sensor placement problem is modeled and solved. A fault detection and identification approach approach is designed for monitoring the power systems. Several IEEE standard systems are employed to validate and evaluate the proposed approach.

TA1a-4 9:30 AM

Performance Analysis of the Tucker HOSVD for Extracting Low-Rank Structure from Multiple Signal-Plus-Noise Matrices

Himanshu Nayar, Rajesh Nadakuditi, University of Michigan, Ann Arbor, United States

The Tucker HOSVD (also known as Tucker3ALS , 3-Mode PCA and 3-Mode SVD) is a popular algorithm for uncovering structure from tensor datacubes. This algorithm has been successfully used in many signal processing, machine learning and data mining applications. In this work, we use recent results from random matrix theory to analyze the performance of the HOSVD algorithm relative to an SVD based alternative . The analysis brings into sharp focus when and the extent to which the HOSVD improves estimation performance. We illustrate the predicted performance improvement using numerical simulations and on a background subtraction application from computer vision.

Track D – Signal Processing and Adaptive Systems

Session: TAb1 – Big Data Signal Processing

Chair: ***Georgios B. Giannakis,*** *University of Minnesota*

TA1b-1 10:15 AM

A Comparison of Clustering and Missing Data Methods for Health Sciences

Ran Zhao, Claremont Graduate University, United States; Deanna Needell, Claremont McKenna College, United States; Christopher Johansen, Jerry Grenard, Claremont Graduate University, United States

In this paper, we compare and analyze clustering methods with missing data in health behavior research. In particular, we propose and analyze the use of compressive sensing's matrix completion along with spectral clustering to cluster health related data. The empirical tests and real data results show that these methods can outperform standard methods like LPA and FIML, in terms of lower misclassification rates in clustering and better matrix completion performance in missing data problems.

TA1b-2 10:40 AM

Discovery of Principles of Nature from Matrix and Tensor Modeling of Large-Scale Molecular Biological Data

Orly Alter, University of Utah, United States

We will describe the use of matrix and tensor decompositions in comparing and integrating different types of large-scale molecular biological data, from different studies of cell division and cancer and from different organisms, to computationally predict previously unknown physical, cellular and evolutionary mechanisms that govern the activity of DNA and RNA. We will present novel generalizations of the singular value decomposition as well as experimental verification and validation of some of the computational predictions.

TA1b-3 11:05 AM

Big Data Clustering Using Random Sampling and Consensus

Panagiotis Traganitis, Konstantinos Slavakis, Georgios Giannakis, University of Minnesota, United States

The advent of Big Data has introduced new challenges and opportunities in the fields of signal processing and machine learning. Clustering huge numbers of high-dimensional data is an undoubtedly complex and time consuming task even for high performance computers. The present paper puts forth a novel randomized dimensionality reduction algorithm for k-means clustering of high-dimensional data based on a random sampling and consensus approach. Simulations assess performance of the proposed method, and compare it with state-of-the-art k-means techniques that rely on random projections.

TA1b-4 11:30 AM

Classification of Streaming Big Data with Misses

Fatemeh Sheikholeslami, Morteza Mardani, Georgios Giannakis, University of Minnesota, United States

`Big Data' classification is hindered by the large volume of data, missing observations, and the need for real-time processing. This paper aims at learning a support-vector-machine (SVM) classifier from such data `on the fly.' Leveraging the decomposable structure of the decision variable, a novel approach is put forth to cope with misses by treating them as unknown scalars. This amounts to first nullifying the missing features, followed by running SVM with a slack variable per datum to rectify the possible data missclassification. Preliminary tests corroborate the effectiveness of the novel approach.

Track F – Biomedical Signal and Image Processing

Session: TAa2 – Neural Spike Train Analysis

Chair: ***Rebecca Willett,*** *University of Wisconsin-Madison*

TA2a-1 8:15 AM

Neural Spike Train Denoising by Point Process Re-weighted Iterative Smoothing

Demba Ba, Massachusetts Institute of Technology, United States; Behtash Babadi, University of Maryland, College Park, United States; Emery Brown, Massachusetts Institute of Technology / Harvard University, United States

We propose a novel iteratively re-weighted least-squares (IRLS) algorithm, termed Point process Re-weighted Iterative SMoothing (PRISM), to solve the total variation denoising problem in one dimension using observations from a point process. PRISM can be implemented using well-established point process analogues of the Kalman smoother. We use a connection

between the Expectation-Maximization algorithm and IRLS to prove the convergence of PRISM. We apply PRISM to neural spiking data acquired from an epileptic patient during general anesthesia induced using the drug propofol, and demonstrate that the algorithm can capture robustly the onset of loss of consciousness at the millisecond time scale.

TA2a-2 8:40 AM

Neurally Inspired Objective Function for Subspace Tracking and Online Feature Learning

Dmitri Chklovskii, Simons Center for Data Analysis, United States

In most approaches to subspace modeling, such as PCA or SVD, and feature learning, such as Sparse Dictionary Learning, existing algorithms are derived by minimizing a (regularized) signal representation error. Although such approaches can be straightforwardly implemented in the online setting, the objective function is typically non-convex and the neural network implementation of such online algorithm often requires biologically implausible non-local learning rules. Here, we propose to minimize the difference between the input and the modeled instance covariance matrix. We show that minimization of such a cost function online naturally leads to a neural network architecture with local learning rules. Our derivation yields both Hebbian and anti-Hebbian learning rules and predicts dependence of learning rate on activity history in agreement with biological observations.

TA2a-3 9:05 AM

Tracking Influence in Dynamic Neural Networks

Rebecca Willett, University of Wisconsin-Madison, United States; Eric Hall, Duke University, United States

Cascading chains of spikes are a salient feature of many biological neural networks. This talk addresses the challenge of tracking how the spikes within a neural network stimulate or influence future spike activity. We adopt an online learning framework well-suited to streaming data, using a multivariate Hawkes model to encapsulate autoregressive features of observed spikes within the neural network. Recent work on online learning in dynamic environments is leveraged not only to exploit the dynamics within the neural network, but also to track that network structure as it evolves. Regret bounds and experimental results demonstrate that the proposed method (with no prior knowledge of the network) performs nearly as well as would be possible with full knowledge of the network.

TA2a-4 9:30 AM

A Design and Implementation Framework for Unsupervised High-resolution Recursive Filters in Neuromotor Prosthesis Applications

Islam Badreldin, Karim Oweiss, University of Florida, United States

In cortically-controlled neuromotor prostheses, the initialization of decoders for motor impaired patients requires concurrently measured neural and motor imagery/observation data. Additionally, the decoder implementation poses a scalability challenge with an increasing number of decoded neurons. We propose a new decoder design framework in which the decoder initialization is unsupervised, the decoder is implemented using recursive filters that can operate at high-resolution sampling of the neural data minimizing the delay introduced in the system, and the decoder gives a smooth control signal expressed by the span of neural data projections onto a low-dimensional space with desirable features for the control task.

Track F – Biomedical Signal and Image Processing

Session: TAb2 – Dynamic Brain Functional Connectivity

Chair: ***Laleh Najafizadeh,*** *Rutgers University*

TA2b-1 10:15 AM

Functional Connectivity Differences in Brain Networks: Contributions of Shared and Unshared Variance

Michael Cole, Rutgers University, United States; Grega Repovs?, University of Ljubljana, United States; Alan Anticevic, Yale University, United States

Investigations of functional connectivity – the statistical dependence among brain activity time series – have provided important insights into the brain systems underlying behavior and cognition. An increasing number of such studies gain these insights by focusing on differences in functional connectivity – between groups, individuals, time periods, or task conditions. One important theoretical issue unaddressed by current approaches is the distinction between shared and unshared variance. This distinction is apparent when considering that adding random fluctuations to one of two tested time series (altering unshared variance) consistently reduces functional connectivity estimates (e.g., correlations, mutual information, coherence), even though this does not systematically affect the amplitude or number of corresponding fluctuations (shared variance) between those two time series. This is inconsistent with the common notion of functional connectivity as the amount of inter-region communication.

We identified methods for isolating differences in shared variance using both simulations and functional magnetic resonance imaging (fMRI). These new approaches may be important for proper characterization of brain network dynamics across groups, individuals, time, and conditions, with many or all neuroscientific recording methods (e.g., fMRI, electroencephalography, local field potentials, multi-unit recording).

TA2b-2 10:40 AM

Beyond Brain Maps: Functional Connectivity versus Task-Based Activations in Mental State Prediction

Irina Rish, IBM T. J. Watson Research Center, United States

Functional connectivity gives rise to a wide range of network-based features that can be much more informative about a particular mental state than the traditional task-based responses (voxel activations). For example, in our fMRI-based analysis of schizophrenia, we observe disruptions of functional networks that cannot be explained by local (area-based) changes in activations, are global in nature as they affect long-distance correlations, and can be also leveraged to achieve high classification accuracy 93% when discriminating between schizophrenic vs control subjects. We also discuss several other examples, such as cocaine addiction and pain, and functional network disruptions associated with such disorders.

TA2b-3 11:05 AM

Approaches for Capturing Dynamic Connectivity States in fMRI data

Vince Calhoun, University of New Mexico, United States

Most fMRI connectivity analysis is focused on generating maps of average connectivity over a 5-10 minute or longer scan session. In this talk I will discuss recent efforts to capture transient, recurring connectivity states and a series of tools for making inferences about individuals in this case. Such approaches enable us to evaluate how long certain individuals or groups spend in each state or in one versus multiple states, and are an extremely promising way to study brain connectivity which is very likely both highly dynamic within an individual over time and highly variable across individuals.

TA2b-4 11:30 AM

Characterizing whole Brain Modulatory Interactions in Resting-State

Bharat Biswal, New Jersey Institute of Technology, United States

Functional connectivity between two brain regions have been shown to be modulated by other brain regions using resting-state functional magnetic resonance imaging (fMRI), which may provide novel insight on dynamics of brain connectivity. However, the spatial distributions and specificity of the modulatory interactions have not been thoroughly examined. The current study investigated modulatory interactions across 169 regions of interest (ROIs) across whole brain using physiophysiological interaction (PPI) analysis on a resting-state fMRI dataset of 125 subjects. Among all the modulatory interactions cross whole brain, there were considerably greater number of negative mdoulatory interactions than positive effects, e.g. in more cases the increase of activity in one region was associated with decreased functional connectivity between two other regions. Lower (medial) visual regions, the cingulate/medial frontal regions and the basal ganglia showed large numbers of positive modulatory interaction effects, while higher (lateral) visual regions, the anterior cingulate and precuneus of the default mode network, and the bilateral precental gyrus regions showed large numbers of negative effects. Lastly, the ROIs were divided into five modules based on graph theory-based analysis, and we observed disproportionally higher number of significant positive modulatory interactions between three regions within one module, suggesting increased within module processing efficiency through positive modulatory interactions. In contrast, there were disproportionally higher number of significant negative modulatory interactions between regions from two modules, suggesting a tendency of between modules segregation through negative modulatory interactions. These results have implications on large scale brain network dynamics.

Session: TAa3 – Distributed Optimization over Networks

Chair: ***Philippe Ciblat,*** *TELECOM ParisTech*

TA3a-1 8:15 AM

The ADMM Algorithm for Distributed Averaging: Convergence Rates and Optimal Parameter Selection

Euhanna Ghadimi, Andr´e Teixeira, Royal Institute of Technology-KTH, Sweden; Michael Rabbat, McGill University, Canada; Mikael Johansson, Royal Institute of Technology-KTH, Sweden

We derive the optimal step-size and over- relaxation parameter that minimizes the convergence time of two ADMM-based algorithms for distributed averaging. Our study shows that the convergence times for given step-size and over-relaxation parameters depend on the spectral properties of the normalized Laplacian of the underlying communication graph. Motivated by this, we optimize the edge-weights of the communication graph to improve the convergence speed even further. The performance of the ADMM algorithms with our parameter selection are compared with alternatives from the literature in extensive numerical simulations on random graphs.

TA3a-2 8:40 AM

Performance Analysis of Multitask Diffusion Adaptation Over Asynchronous Networks

Roula Nassif, Cédric Richard, André Ferrari, Université de Nice Sophia-Antipolis, France; Ali H. Sayed, University of California, Los Angeles, France

Diffusion adaptation enables networked agents to interact cooperatively to estimate a common parameter of interest, or a collection of related parameters that we refer to as tasks. In multitask learning, different clusters within the network are interested in estimating their own parameter models, and interactions among adjacent clusters are motivated by their desire to enforce certain measures of similarly between their tasks. In prior work on multitask diffusion adaptation, we focused on the behavior of synchronous networks where all agents act synchronously in updating their estimates. In this work, we examine adaptation and learning under asynchronous conditions where networks are subject to various sources of uncertainties such as changing topologies, random link failures, and agents turning on and off randomly. We pursue a detailed mean-square analysis and examine how asynchronous events interfere with the learning performance.

TA3a-3 9:05 AM

On the Convergence of an Alternating Direction Penalty Method for Nonconvex Problems

Sindri Magnússon, P. Chathuranga Weeraddana, KTH Royal Institute of Technology, Sweden; Michael Rabbat, McGill University, Canada; Carlo Fischione, KTH Royal Institute of Technology, Sweden

Distributed and scalable methods for solving large scale structured convex optimization problems have recently been heavily investigated. However, the requirement of scalability is also crucial for more challenging nonconvex problems, e.g. the optimal power flow problem in smart grids and general consensus problems in multi-agent networks. Problem structures commonly exploited to develop distributed/scalable algorithms for convex problems can often be found in large scale nonconvex problems as well. This paper investigate approaches for solving separable optimization problems with linear coupling constraints, where the objective functions are nonconvex.

TA3a-4 9:30 AM

Decentralized Regression with Asynchronous Sub-Nyquist Sampling

Hoi To Wai, Anna Scaglione, University of California, Davis, United States

When capturing a sensor field, local analog to digital converters are not coherent in time and are also characterized by a sampling frequency offset. Some of these delays may be due to replay attacks in the system. The paper explores how to solve decentralized optimization problems can lead to a consensus in the estimate of a latent parameter vector signal that is Band Limited, when the sensor observations are plagued by heterogenous sampling frequency and time offsets.

Session: TAb3 – Latest Coding Advances

Chair: ***Hamid Jafarkhani,*** *University of California, Irvine*

TA3b-1 10:15 AM

Joint Space-Time Code Designs for Multiple Access Channels

Tianyi Xu, InterDigital Communications, Inc., United States; Xiang-Gen Xia, University of Delaware, United States

A joint code design for multiple access channels (MAC) was proposed by G$\ddot{a}$rtner and B$\ddot{o}$lcskei, based on the characterization of the error events. In this paper, we propose two new code designs. The first one has a better performance and a higher symbol rate for two-user MAC with two transmit antennas at both users, while the same diversity order is achieved as the design by G$\ddot{a}$rtner and B$\ddot{o}$lcskei when both users are in errors. The other one is a systematic design for multiple users and multiple transmit antennas, which achieves the maximum diversity across all the users when errors occur in a group of users.

TA3b-2 10:40 AM

Quantized Distributed Reception Techniques for MIMO Wireless Systems

Junil Choi, David Love, Purdue University, United States

Distributed reception techniques leverage nodes spread over a geographic area that can pass only a few bits of information to a centralized processor. Using this quantized information, the centralized processor aims to recover the transmitted signal. In this paper, we propose distributed reception techniques for multiple antenna spatial multiplexing transmission. We show how the distributed array can efficiently recover the transmitted vector.

TA3b-3 11:05 AM

Generalized Spatial Modulation for Large-Scale MIMO Systems: Analysis and Detection

Theagarajan Lakshmi Narasimhan, Patchava Raviteja, Ananthanarayanan Chockalingam, Indian Institute of Science, India

Generalized Spatial modulation (GSM) uses n_t antenna elements but fewer radio frequency chains (n_{rf}) at the transmitter. Spatial modulation and spatial multiplexing are special cases of GSM with $n_{rf}=1$ and $n_{rf}=n_t$, respectively. In GSM, apart from conveying information bits through n_{rf} modulation symbols, information bits are also conveyed through the indices of the active n_{rf} transmit antennas. In this paper, we derive analytical bounds on the codeword and bit error probabilities of maximum likelihood detection in GSM. The bounds are shown to be tight at medium to high signal-to-noise ratios (SNR). We also present a low-complexity detection algorithm based on reactive tabu search (RTS) for GSM in large-scale MIMO systems. Simulation results show that the proposed algorithm performs well and scales well in complexity.

TA3b-4 11:30 AM

Bandwidth Analysis of Low-Complexity Decoupling Networks for Multiple Coupled Antennas

Ding Nie, Bertrand Hochwald, University of Notre Dame, United States

In MIMO communication systems where coupled antennas are driven by independent amplifiers, a decoupling network is often used to eliminate power reflection from the antennas. The realization of the decoupling network is not unique, and different realizations have major differences in complexity and bandwidth. Recent designs for low-complexity networks show that a minimum of N^2+N impedances are generally needed to achieve decoupling for N antennas. This paper provides a perturbation analysis of the bandwidth, and shows that a decoupling network with N^2+2N impedances can often achieve a much wider bandwidth than N^2+N impedances. We illustrate using a three-antenna example.

Track B – MIMO Communications and Signal Processing

Session: TAa4 – Enhanced MIMO for LTE-A and 5G Systems

Chair: ***Fred Vook,*** *Nokia Siemens Networks*

TA4a-1 8:15 AM

3D Channel Models for Elevation Beamforming and FD-MIMO in LTE-A and 5G

Jianzhong (Charlie) Zhang, Yang Li, Young-Han Nam, Samsung, United States

Elevation beamforming and Full Dimension MIMO (FD-MIMO) is an active area of research and standardization in 3GPP LTE-A, and initial investigation has shown that promising (3-5x) cell capacity and cell edge gain can be achieved with these new techniques. In an FD-MIMO system, a 2-dimensional (2D) active array is deployed to support both elevation beamforming and conventional azimuth beamforming, which resulting in much higher MU-MIMO capability compared to conventional MIMO systems. To evaluate effectiveness of elevation beamforming and FD-MIMO, a 3-dimention (3D) channel model has been recently developed in 3GPP. This paper summarizes the latest 3D channel model development and highlights the main differences compared to a legacy 2D channel model. Meanwhile, we also report several key insights gained from this recent study in 3GPP on 3D channel model, including practical scenarios, system design considerations, as well as initial calibration results and its implications.

TA4a-2 8:40 AM

Advanced Antenna Solutions for 5G Wireless Access

Erik Dahlman, Stefan Parkvall, David Astely, Hugo Tullberg, Ericsson, Sweden

The use of multiple transmit antennas at the base station and device side play an important role already in current 4G/LTE systems, enhancing system performance and extending the data rates that can be provided to the end user. For the future (5G) wireless-access solution advanced antenna solutions are expected to play an even more pronounced role. 5G wireless access needs to provide substantially higher data rates, up to the multi-Gbps range in specific scenarios and with hundreds of Mbps to be generally available in urban/suburban environments, as well handle traffic volumes hundreds of times higher than today. Advanced multi-antenna transmission will be key to fulfill both the requirements. At the same time, 5G wireless is expected to extend to frequency-range-of-operation beyond 10 GHz and into the mmw range. The corresponding smaller wave length will be an enabler of more advanced antenna configurations with a much larger number of controllable antenna elements compared to the antenna configurations of today. In this paper we discuss advanced antenna solutions for 5G wireless access, what are the opportunities, alternatives, and possible obstacles.

TA4a-3 9:05 AM

Multi-Layer Precoding for Full-Dimensional MIMO Systems

Ahmed Alkhateeb, University of Texas at Austin, United States; Geert Leus, Delft University of Technology, Netherlands; Robert W. Heath Jr., University of Texas at Austin, United States

Full-dimensional multiple-input multiple-output (FD-MIMO) systems boost spectral efficiency by offering orders of magnitude increase in multiplexing gains. The overhead associated with estimating and acquiring channel state information for the large number of antennas, however, is a performance limiting factor. In this paper, we consider FD-MIMO downlink channel, and propose low-complexity channel estimation and 3D beamforming algorithms that exploit the spatial correlation of the large MIMO channel. The performance of the proposed techniques is analyzed and compared with other FD-MIMO precoding algorithms.

TA4a-4 9:30 AM

Massive MIMO for mmWave systems

Frederick Vook, Timothy Thomas, Nokia Solutions and Networks, United States

Multiple-Input, Multiple-Output (MIMO) technology has been successfully deployed on a wide scale in current “4G” cellular systems and is expected to play a key role in “5G” systems, which will likely be rolled out in the year 2020 and beyond. Given the current state of world-wide spectrum allocations for broadband communications, it is anticipated that a class of 5G systems will be deployed in the cm-wave (3-30 GHz) and mm-wave (30-300 GHz) bands. As a result, the unique characteristics and challenges of these bands have led to significant research efforts into the design and performance tradeoffs associated with deploying MIMO technology in these bands. In this paper, we present a framework for beamforming and MIMO technology for mm-wave systems were we focus on techniques for obtaining channel state information, various implementation and architecture issues, and overall system performance. We focus on the application of large scale arrays with “Massive MIMO” to the enhanced-local-area deployment scenario.

Session: TAb4 – Cognitive Radio I

Chair: ***Paul de Kerret,*** *Eurecom*

TA4b-1 10:15 AM

Statistically Coordinated Precoding for the MISO Cognitive Radio Channel

Paul de Kerret, Miltiades Filippou, David Gesbert, Eurecom, France

We study a cognitive radio setting where the two transmitters aim at coordinating to maximize the rate of the secondary user subject to a primary rate constraint. Considering a realistic channel state information scenario where each transmitter has solely access to the instantaneous knowledge of its direct channel, we let the transmitters exploit their statistical knowledge of the multi-user channel to coordinate. This setting gives rise to a Team Decisional problem. We develop a novel coordination scheme where the transmitters coordinate without any exchange of information or any iteration.

TA4b-2 10:40 AM

Simultaneous Detection and Estimation based Spectrum Sharing in Cognitive Radio Networks

Jyoti Mansukhani, Priyadip Ray, Indian Institute of Technology Kharagpur, India; Pramod Varshney, Syracuse University, United States

A new spectrum sharing strategy based on coupled detection and estimation is proposed for cognitive radio networks. The strategy consists of the following steps: First the secondary user (SU) listens to the spectrum allocated to the primary user (PU) to detect the state of the PU and transmits if the PU is inactive. However, if the PU is active, the SU estimates the PU location and then makes a decision about the reliability of the estimate. The SU transmits via beamforming, with a null in the estimated direction of the PU, only when the estimate is classified as reliable.

TA4b-3 11:05 AM

Interference-Temperature Limit for Cognitive Radio Networks with MIMO Primary Users

Cristian Lameiro, University of Cantabria, Spain; Wolfgang Utschick, Technische Universität München, Germany; Ignacio Santamaria, University of Cantabria, Spain

In this paper, we derive the interference-temperature (IT) limit for a multi-antenna primary user (PU) that has a rate constraint. While in the case of a single-stream PU there is a one-to-one mapping between IT and achievable rate, this property does not hold anymore when a multiple-input multiple-output (MIMO) system is considered. For a MIMO user, we derive a closed-form expression for the maximum IT that can be tolerated by identifying the worst-case interference covariance matrix, which results in a multilevel waterfilling problem.

TA4b-4 11:30 AM

Competitive Dynamic Pricing under Demand Uncertainty

Yixuan Zhai, Qing Zhao, University of California, Davis, United States

We consider a multi-seller dynamic pricing problem with unknown demand models. In this problem, each seller offers prices sequentially to a stream of potential customers and observes either success or failure in each sale attempt. The underlying demand model is unknown and can take a finite number of possible forms. The problem is formulated as a repeated game with incomplete information. Based on likelihood ratio test, we develop a dynamic pricing strategy that leads to an efficient sequential Nash Equilibrium and offers a finite regret with respect to the ideal case of a known demand model.

Session: TAa5 – Recent Advances in Speech Coding

Chair: ***Tokunbo Ogunfunmi,*** *Santa Clara University*

TA5a-1 8:15 AM

Large Margin Nearest Neighborhood Metric Learning for I-Vector Based Speaker Verification

Waquar Ahmad, Harish Karnick, Rajesh M Hegde, Indian Institute of Technology Kanpur, India

A new large margin nearest neighborhood metric learning (LMNN) method for i-vector based speaker verification is proposed in this paper. In general, a verification decision is taken by computing the cosine distance between the i-vectors of the test utterance and the claimed identity. LMNN metric is learned from the examples and can be viewed as a linear transformation of the input i-vector space of the training and test utterance. In this work, the metric is learned with the objective of reducing the distance between the i-vectors of same class of speaker, while impostors are separated by a large margin. The metric learned in this manner leads to a better speaker verification performance. Speaker verification experiments are then conducted on the NIST 2008 and YOHO speaker verification databases. Experimental results indicate a reasonable improvement in performance, when compared to i-vector based speaker verification methods which use conventional cosine scoring.

TA5a-2 8:40 AM

Performance Enhanced Scalable Wideband Speech Coding for IP Networks

Tokunbo Ogunfunmi, Koji Seto, Santa Clara University, United States

Abstract—The scalable wideband speech coding scheme based on the internet low bitrate codec (iLBC) was previously presented and achieved speech quality equivalent to ITU-T G.729.1 at high bit rates for wideband signals. The codec adopted a split-band structure which employed the narrowband codec based on the iLBC coding scheme to encode both the lower- and higher-band signals. This structure provided the interoperability with the narrowband codec in a core layer and achieved high speech quality at high bit rates; however, the performance was limited at low bit rates. In this paper, we explore various approaches to improve performance under both clean and lossy channel conditions. The bit rate scalable structure is used to achieve flexibility in terms of bit rates for voice over IP (VoIP) applications as previously employed, whereas the use of different coding schemes for the core layer and the enhancement layers is explored without regard to the interoperability. The proposed codec is expected to be more robust to packet loss than state-of-the-art wideband codecs and still achieves similar voice quality to those codecs under clean channel condition.

TA5a-3 9:05 AM

Adaptive Control of Applying Band-Width for Post Filter of Speech Coder Depending on Pitch Frequency

Hironobu Chiba, Univ. of Tsukuba, Japan; Yutaka Kamamoto, Takehiro Moriya, Noboru Harada, Nippon Telegraph and Telephone Corp., Japan; Shigeki Miyabe, Takeshi Yamada, Shoji Makino, Univ. of Tsukuba, Japan

Most speech codecs utilize a post-filter that emphasizes pitch structures to enhance perceptual quality at the decoder. Particularly, the bass post-filter used in ITU-T G.718 performs an adaptive pitch enhancement for a lower fixed frequency band. This paper describes a new post-filtering method to improve the bass post-filter by means of a frame-by frame adaptive control of frequency band and gain depending on the pitch frequency of decoded signal. We have confirmed the improvement of the speech quality with the developed method through the objective and subjective evaluations.

TA5a-4 9:30 AM

Classification of Sonorant Consonants Utilizing Empirical Mode Decomposition

Ashkan Ashrafi, San Diego State University, United States; Stanley Wenndt, Air Force Research Laboratory, United States

In this paper, a method to classify nasal utterance among sonorant consonants utilizing empirical mode decomposition (EMD) is introduced. In this method, each audio signal is divided into overlapping 20 millisecond frames. Then each frame's signal is decomposed by using the EMD. Four different features are extracted from each frame to create a vector. These vectors are employed to train a support vector machine (SVM) with radial basis functions. A different set of audio signals are used to validate the SVM model. The results show an overall correct identification rate of 91.19\% for nasals and 89.74\% for semivowels

Track H – Speech, Image and Video Processing

Session: TAb5 – Historic Photographic Paper Identification via Textural Similarity Assessment

Co-Chairs: ***Andrew G. Klein,*** *Worcester Polytechnic Institute* ***and Patrice Abry,*** *Ecole Superieure de Lyon (CNRS)*

TA5b-1 10:15 AM

Automated Surface Texture Classification of Photographic Print Media

Paul Messier, Paul Messier LLC, United States; Richard Johnson, Cornell University, United States

This paper introduces a project to automatically characterize the surface texture of inkjet and black and white photographic printing media. Texture is a key feature in the manufacture and use of photographic paper. Raking light photomicrographs reveal texture through a stark rendering of highlights and shadows. Two raking light datasets were created for inkjet and black and white print media. Using different approaches, four university teams were successful in detecting affinities and outliers built into these datasets, demonstrating the feasibility of automatic texture classification. These methods have applications for cultural heritage scholarship and for industrial quality control and design.

TA5b-2 10:40 AM

Eigentextures: An SVD Approach to Automated Paper Classification

William Sethares, Atul Ingle, Tomas Krc, University of Wisconsin, United States; Sally Wood, Santa Clara University, United States

This paper investigates a method of texture classification using the eigentexture approach. This method assembles a collection of small patches from each class of photographic paper; the patches are gathered into a large matrix and simplified so as to retain only the most relevant eigendirections using an SVD. During the classification stage, a number of similarly-sized patches are drawn from an unknown photographic paper. Each of these patches is compared to the classes, and a similarity measure is created by a kind of voting procedure. Whichever class receives the most votes is the most likely class. This paper provides two kinds of analyses. First is a rate-of-convergence result that can be used to estimate parameters within the model and that can be used to estimate the quality of the classification. Second is an analysis of a randomized-resampling implementation that reduces the computational burden as the algorithm is scaled for larger data sets. The advantages and disadvantages of this procedure are investigated in the Historic Photo Paper Classification dataset and in a collection of inkjet papers organized to compare different classification methods.

TA5b-3 11:05 AM

Texture Classification via Area-Scale Analysis of Raking Light Images

Andrew G. Klein, Western Washington University, United States; Anh Do, Christopher Brown, Worcester Polytechnic Institute, United States; Philip Klausmeyer, WAM, United States

An image processing algorithm for photographic paper texture classification is developed based on area-scale analysis. This analysis has been applied in surface metrology, and relies on the fact that the measured area of a surface depends on the scale of observation. By comparing relative areas at various scales, the technique can compute topological similarity of two surfaces. Results show the algorithm is successful in detecting affinities among similarity groupings within the HPPC dataset.

TA5b-4 11:30 AM

Hyperbolic Wavelet Transform for Historic Photographic Paper Classification Challenge

Stephane Roux, Patrice Abry, ENS Lyon, France; Herwig Wendt, ENSHEEIT-IRIT, France; Stephane Jaffard, Paris Est University, France

Photographic paper texture characterization constitutes a challenging image processing task and an important stake both for manufacturers and art museums. The present contribution shows how the Hyperbolic Wavelet Transform, thanks to its joint multiscale and anisotropic natures, permits to achieve an accurate photographic paper texture analysis. A cepstral-type distance, constructed on the coefficients of the Hyperbolic Wavelet Transform, is then used to measure similarity between pairs of paper textures. Postprocessing of the the similarity matrix enables to achieve a relevant non supervised classification of photographic papers. This methodology is applied to a test dataset made available in the framework of the Historic Photographic Paper Classification Challenge, led by the Museum of Modern Art (NYC).

Track E – Array Signal Processing

Session: TAa6 – Compressive Methods in Radar

Chair: ***Athina Petropulu,*** *Rutgers University*

TA6a-1 8:15 AM

Sparse Arrays, MIMO, and Compressive Sensing for GMTI Radar

Haley Kim, Alexander Haimovich, New Jersey Institute of Technology, United States

Despite advances in radar, important gaps remain in the ability of ground moving target indicator (GMTI) radars to detect slow moving targets embedded in ground clutter. This work proposes a GMTI radar combining synergistic elements from four themes: space-time adaptive processing (STAP), random arrays, multiple-input multiple-output (MIMO) radar, and compressive sensing. STAP supports joint space-time processing for detecting moving targets in ground clutter. Large, random arrays are undersampled adaptive arrays that support improved angle-Doppler resolution and lower minimum detectable velocity (MDV), at the cost of higher sidelobes. Even though random arrays have been studied as early as the 1970's, new results reveal interesting links to compressive sensing. MIMO provides further improvements in angular resolution and MDV, while supporting waveform diversity and additional savings in the number of sensors. Compressive sensing algorithms are designed to cope with ambiguities introduced by undersampling. We propose an algorithm for target detection and analyze its performance for detecting, slow ground targets.

TA6a-2 8:40 AM

Efficient Linear Time-Varying System Identification Using Chirp Waveforms

Andrew Harms, Duke University, United States; Waheed Bajwa, Rutgers University, United States; Robert Calderbank, Duke University, United States

Linear time-varying systems (LTV) are operators that impart a time shift and frequency shift to a probing waveform and are important models in applications such as radar and channel estimation. In this paper, we present a novel scheme for efficient identification of LTV systems that uses linear frequency modulated (LFM) pulses. In previous work, we showed that this scheme offers asymptotically perfect identification, even in the presence of noise, with a diverse selection of LFM pulses. In this work, we show that we can adaptively choose the LFM pulses to efficiently eliminate ambiguity in the LTV system identification.

TA6a-3 9:05 AM

Robust Multipath Exploitation Radar Imaging in Urban Sensing Based on Bayesian Compressive Sensing

Qisong Wu, Yimin Zhang, Moeness Amin, Fauzia Ahmad, Villanova University, United States

Radar-based urban sensing has attracted considerable attention in many civil and military applications. In particular, through-the-wall radar imaging (TWRI) has the capability of acquiring high-resolution images of targets of interest behind an opaque obstacle. Compressive sensing (CS) techniques provide an effective means for this purpose because target activities in TWRI applications are typically sparse. Among different CS techniques that are currently available, those based on sparse Bayesian learning generally demonstrate increased robustness against dictionary coherence and noise when compared their counterparts based on greedy and basis pursuit algorithms. In particular, the multi-task Bayesian CS techniques provide effective solutions to a large class of group sparse problems due to, for example, frequency-dependent reflectivity. An important class of group sparsity in TWRI applications stems from the existence of multipath propagation. Improper processing of unresolved multipath signals due to wall reflections may yield ghost targets that undesirably clutter the scene. One of the effective techniques to avoid such problems is multipath exploitation. In CS, this can be implemented by incorporating the multipath propagation model in the sensing dictionary. To achieve effective exploitation of unresolvable multipath signals, existing CS techniques assume perfect knowledge of the wall positions that are embedded in the dictionary matrix. In practice, however, the assumed wall positions generally have errors. Even a small error in the wall position, on the order of a fraction of the wavelength, would yield considerable phase error in the wall reflected waves, generating discrepancies between the assumed sensing dictionary and the actual scene and, thereby, reducing the imaging quality and sparse scene recoverability. The main objective of this paper is to develop a robust multi-task Bayesian CS technique that accounts for the wall position uncertainties and provides robust high-resolution target images in such scenarios.

TA6a-4 9:30 AM

Joint Sparse and Low-rank Model for Radio-Frequency Interference Suppression in Ultra-wideband Radar Applications

Lam Nguyen, Army Research Laboratory, United States; Minh Dao, Trac Tran, Johns Hopkins University, United States

Radio-frequency interference is the most common, and also the most challenging type of interference or noise source that has a direct impact on the performance of ultra-wideband radar systems in various practical application settings. This paper proposes a robust and adaptive technique for the separation and then suppression of RFI signals from ultra-wideband radar data via modeling RFI as low-rank components in a joint optimization framework. We advocate a joint sparse-plus-low-rank recovery approach that simultaneously solves for (i) UWB radar signals as sparse representations with respect to a dictionary containing transmitted waveforms; and (ii) RFI signals as a low-rank structure.

Track E – Array Signal Processing

Session: TAb6 – Statistical Inference in Smart Grids

Co-Chairs: ***H. Vincent Poor,*** *Princeton University* ***and Yue Zhao,*** *Stanford University*

TA6b-1 10:15 AM

Revisiting Cyclo-Stationary Random Signal Analysis for Modeling Renewable Power

Masood Parvania, University of California, Davis, United States; Francesco Verde, Universita' Federico II di Napoli, Italy; Anna Scaglione, University of California, Davis, United States; Donatella Darsena, Giacinto Gelli, Universita' Federico II di Napoli, Italy

In this paper we revisit the theory of cyclo-stationary processing to study multivariate cyclo-stationary random processes and of their derivatives. The objective is to model Wind and Solar power generation and of their ramping characteristics, going beyond the essential but limiting task of forecasting. The models are are meant to quantify the risk of synchronizing demand and generation to the random excursions or renewable power using a mutli-settlement dispatch. The also can help the compression and communication of local sensor data in real time.

TA6b-2 10:40 AM

Integrating PMU-data-driven and Physics-based Analytics for Power Systems Operations

Yang Chen, Le Xie, P. R. Kumar, Texas A&M University, United States

This work studies the data-driven approaches using phasor measurement unit (PMU) data, and the integrations with the physics-based analytics. The principal component analysis (PCA) based dimensionality reduction is first applied to explore the underlying dimensionality of power systems from the massively deployed PMU data. Then the physical interpretations are analyzed for the power engineering insight: spatial interpretation suggests the coherency of generators; temporal analysis indicates the time-scale separations of power system operations. Numerical examples using realistic PMU data are conducted to demonstrate the results.

TA6b-3 11:05 AM

Sensor Placement for Real-Time Dynamic State Estimation in Power Systems: A Structural Systems Approach

Pedro Rocha, University of Porto, Portugal; Sergio Pequito, Carnegie Mellon University, United States; Pedro Aguiar, Paula Rocha, University of Porto, Portugal; Soummya Kar, Carnegie Mellon University, United States

This paper studies sensor placement design for efficient dynamic real-time state estimation in electric power networks. Given a (linearized) dynamic physical model of the power system, efficient sensor placement strategies are proposed that minimize the observability-index of the system. The observability-index plays a key role in determining the minimum window length of filters that guarantee stable estimation error. Moreover, the problem addressed in the structural systems framework, i.e., the placement strategies are obtained on the basis of the sparsity pattern of the system coupling matrix, and the design guarantees hold for almost all numerical parametric realizations of the system.

TA6b-4 11:30 AM

Dynamic Joint Outage Identification and State Estimation in Power Systems

Yue Zhao, Stanford University, United States; Jianshu Chen, University of California, Los Angeles, United States; Andrea Goldsmith, Stanford University, United States; H. Vincent Poor, Princeton University, United States

Joint outage identification and state estimation in a dynamically evolving power system is studied. A linear dynamic system model is employed that characterizes the state evolution in a power system. The evolving joint posterior of outage hypotheses and network states are developed in closed form. Metrics that characterize the real-time and steady state performance of optimal joint detection and estimation are derived. Based on the developed metrics, sensor locations for optimizing the joint detection and estimation performance are found efficiently. Simulation results demonstrate significant performance gains from using the optimal joint detector and estimator with the optimal sensor locations.

Track G – Architecture and Implementation

Session: TAa7 – Computer Arithmetic I

Chair: ***Neil Burgess,*** *ARM Inc.*

TA7a-1 8:15 AM

Ultra-Light Weight Hardware Accelerator Circuits for Data Encryption in Wearable Systems

Sanu Mathew, Sudhir Satpathy, Vikram Suresh, Ram Krishnamurthy, Intel Corporation, United States

Securing data on energy-constrained wearable systems requires a rethink on how we build hardware accelerators than can operate in ultra-low area/power systems. This paper will describe the design and implementation of a 2090-gate nanoAES hardware accelerator that uses Galois-field polynomial-based micro-architectural co-optimization to achieve 11x higher energy-efficiency, while offering the full security of AES-128. This design represents the minimal hardware require to support the AES algorithm with integrated round-key generation, achieving nominal encrypt/decrypt throughputs of 432/671Mbps, measured at 0.9V, 25C.

TA7a-2 8:40 AM

Arithmetic Operations in the Heterogeneous System Architecture

Michael Schulte, AMD Research, United States

The Heterogeneous System Architecture (HSA) provides specifications to seamlessly integrate CPUs, GPUs, and other computing elements through shared virtual memory, user mode queuing, the HSA intermediate language (HSAIL), cache coherence, and signaling. This paper describes HSA arithmetic operations, discusses how these operations can be efficiently implemented, and provides ideas for future computer arithmetic research for heterogeneous systems.

TA7a-3 9:05 AM

Low Latency is Low Energy

David Lutz, Neil Burgess, ARM, United States

For an out-of-order CPU, the multi-cycle execution units (e.g., multipliers or dividers or floating-point adders) consume only a small fraction of the area and power used by the core. By reducing the latency of these units, we can often complete a task early, saving large amounts of total energy. We describe a simple formula to gauge the relationship between execution unit power, core power, execution unit latency, and overall energy required for a task. We then use that formula to argue for lower latency execution, even if the power of the execution units has to be increased.

TA7a-4 9:30 AM

Optimizing DSP Circuits by a New Family of Arithmetic Operators

Javier Hormigo, Julio Villalba, Universidad de Malaga, Spain

A new family of arithmetic operators to optimize the implementation of circuits for digital signal processing is presented. Thanks to use of a new technique which reduces the quantification errors, the proposed operators may decrease significantly the size of the circuits required for most applications. That means a simultaneous reduction of area, delay and power consumption.

Session: TAb7 – MIMO Sensing

Chair: ***Jian Li,*** *University of Florida*

TA7b-1 10:15 AM

Bi-Static MIMO Radar Operations for Range-Folded Clutter Mitigation

Yuri Abramovich, WR Systems Ltd., United States; Gordon Frazer, DSTO, Australia; Geoffrey San Antonio, Naval Research Laboratory, United States; Ben Johnson, Colorado School of Mines, United States

In certain radar applications range-folded clutter returns can significantly degrade radar performance if the properties of the range-folded clutter are significantly different from the properties of the “in-range” clutter. Typical examples include skywave over-the-horizon radar (OTHR) operating in high waveform repetition (aircraft detection) mode and sited such that either Northern Aurora or Equatorial Anomaly reflections containing spread Doppler clutter (SDC) are present at the ranges of the second or higher range ambiguity. There are a number of potential solutions to this problem including judicious selection of waveform repetition frequency, the use of non-recurrent waveforms, and the method we discuss more fully in this paper, that of exploiting the bistatic separation of the system transmitter and receiver that is typical in OTHR. No single approach to this problem is suitable in every case so it is important that the radar designer implement a system with the scope to introduce the appropriate technique in any given circumstance. When ionosheric propagation conditions permit it is possible to exploit the significantly bi-static location of the transmitting (Tx) and receiving (Rx) positions. With appropriately chosen bi-static geometry, both Tx and Rx arrays finger beams overlap at one-range ambiguity operational distances, while the range-folded reflections from the second and higher range ambiguities SDC arrive at the Rx beampattern sidelobes that can be properly controlled. Apart from more restrictive propagation conditions that have to be equally good to support the two geographically different Tx and Rx sites, conventional (SIMO) implementation of this principle, has one further problem. The sidelobe level of a typical modern OTHR Tx antenna array, consisting of 16-24 elements, is typically not low enough to completely ignore range-folded spread clutter illuminated by these sidelobes. Within this bi-static geometry it is therefore not only required to implement range-dependent Rx array beam steering and sidelobe mitigation, but the same range-dependent beam steering and sidelobe mitigation is required for Tx array as well. It has been demonstrated that improved performance in this case can be achieved by MIMO technology introduced in this paper.

TA7b-2 10:40 AM

Large Phased Array Antenna Calibration Using Radar Clutter and MIMO

Matthew Brown, Mitch Mirkin, Dan Rabideau, MIT Lincoln Laboratory, United States

Phased array radar beamforming is degraded by phase and gain deviations across antenna subarrays. Elements within an individual subarray may be calibrated by injecting a known signal into each receiver (e.g., via a loop back path or via mutual coupling), but this approach does not correct transmission or array deformation errors. An alternative approach for removing these subarray errors is to leverage the digital AESA (active electronically scanned array) architecture to calibrate on radar clutter while the radar is in flight. An antenna calibration algorithm that removes transmit and receive subarray errors using MIMO (multiple input, multiple output) waveforms is described and simulated.

TA7b-3 11:05 AM

High Resolution Imaging for MIMO Forward Looking Ground Penetrating Radar

Jian Li, Ode Ojowu, Luzhou Xu, University of Florida, United States; John Anderson, Howard University, United States; Lam Nguyen, Army Research Laboratory, United States

Forward-Looking Ground Penetrating Radar (FLGPR) can be used for detecting landmines. The detection process involves generating synthetic aperture radar (SAR) images using the standard backprojection (BP). The BP approach suffers from poor resolution and high sidelobe problems. This paper focuses on enhancing imaging resolution and reducing sidelobes using the Sparse Iterative Covariance-based Estimation (SPICE). A MIMO FLGPR developed by the Army Research Laboratory (ARL) is used for analysis.

TA7b-4 11:30 AM

Structure Health Monitoring Exploiting Mimo Ultrasonic Sensing and Group Sparse Bayesian Learning

Qisong Wu, Yimin Zhang, Moeness Amin, Andrew Golato, Sridhar Santhanam, Fauzia Ahmad, Villanova University, United States

Real-time imaging of defects in thin-walled structures using guided ultrasonic waves has emerged as a significant application area in structure health monitoring (SHM). In the proposed multiple-input multiple-output (MIMO) ultrasonic sensing system, a network of piezoelectric (PZT) transducers is affixed to the structure. On impulsive excitation of the transducers, elastic stress waves called Lamb waves propagate through the thin-walled structure and interact with defects and plate boundaries before arriving at the receiving transducers. The received signals at the receive transducers can be very complex with significant overlapping of modal pulses because of the propagation dispersion of the Lamb waves. The underlying SHM sensing problem invites application of sparse signal reconstruction techniques with the consideration of multi-dimensional group sparsity for effective defect imaging. First, the defects have an extended spatial occupancy that is clustered in the image domain. Second, the use of MIMO sensing methodologies forms another dimension of group sparsity and, as such, increases the overall multi-dimensional clustered problem. To provide reliable and high-resolution defect imaging, we propose the exploitation of sparse Bayesian learning that accounts for the multi-dimensional group sparsity of the defects due to their clustered spatial occupancy and the multiple-aspect MIMO observations. Sparse Bayesian learning techniques have shown to provide robustness for high-resolution signal reconstruction due to its insensitivity to dictionary coherence and have the flexibility of effective exploitation of the signal structure. As such, the proposed approach result in an effective high-resolution imaging methodology which is robust to noise and speckles. The superiority of the proposed technique over the state-of-the-art sparse signal reconstruction techniques will be demonstrated through simulations.

Track B – MIMO Communications and Signal Processing

Session: TAa8 – Channel Estimation and MIMO Feedback 8:15 AM–9:55 AM

Chair: ***Ananthanarayanan Chockalingam,*** *Indian Institute of Science*

TA8a1-1

Channel Estimation in Millimeter Wave MIMO Systems with One-Bit Quantization

Jianhua Mo, University of Texas at Austin, United States; Philip Schniter, Ohio State University, United States; Robert W. Heath Jr., University of Texas at Austin, United States

We develop a channel estimator for millimeter wave (mmWave) multiple input multiple output (MIMO) systems with with one-bit ADCs. Since the mmWave MIMO channel is sparse due to the propagation characteristics, the estimation problem is formulated as a one bit compressed sensing problem. We use the generalized approximate message passing (GAMP) algorithm to solve this optimization problem. The initial simulation results show that GAMP can exploit sparsity to reduce mean squared error in the important low SNR region.

TA8a1-2

Maximum-Likelihood Joint Channel Estimation and Data Detection for Space Time Block Coded MIMO Systems

Haider Alshamary, Weiyu Xu, University of Iowa, United States

This paper considers exact maximum likelihood (ML) joint channel estimation and data detection for orthogonal space time block coded (OSTBC) multiple input multiple output (MIMO) systems. We propose an efficient algorithm which achieves exact ML blind data detection even for non-constant-modulus constellations. To the best of our knowledge, this is the first algorithm which efficiently achieves exact ML blind detection for OSTBC MIMO systems with non-constant-modulus constellations. Theoretical and simulation results validate performance and complexity improvements.

TA8a1-3

Cramer-Rao Bound for Blind Channel Estimation in Cyclic Prefixed MIMO-OFDM Systems With Few Received Symbols

Borching Su, Kai-Han Tseng, National Taiwan University, Taiwan

In this paper, a Cramer-Rao bound (CRB) for blind channel estimation in cyclic prefixed MIMO-OFDM systems is derived. The derived bound is valid for arbitrary numbers of transmit antennas, received antennas, and received symbols available for blind channel estimation, and serve as a benchmark of performances of several recently proposed subspace-based algorithms. Computer simulations are conducted to compare these algorithms with the derived bound. The results show that there are still rooms for improvement for the currently available blind channel estimation algorithms.

TA8a1-4
Efficient MIMO Sparse Channel Estimation Using LTE Sounding Reference Signal
Jeng-Kuang Hwang, Jen-Hao Liu, Chien-Min Chen, Chuan-Shun Lin, Yuan Ze University, Taiwan

In order to make full use of various LTE MIMO transmission modes, we aim for a feasible MIMO channel estimation scheme with high accuracy and low complexity. Exploiting the sounding reference signal and channel sparsity, an efficient MIMO channel estimation algorithm is derived in terms of both the maximum likelihood estimation and minimum description length criterion for tap selection. The scheme exhibits excellent performance for sparser channel. Furthermore, its complexity is quite low due to the use of FFT and power sorting. Simulation and real-world experimental results of a 2x2 MIMO system are demonstrated to confirm the above merits.

TA8a1-5
Impact of Received Signal on Self-interference Channel Estimation and Achievable Rates in In-band Full-duplex Transceivers
Dani Korpi, Lauri Anttila, Mikko Valkama, Tampere University of Technology, Finland

This paper analyzes the effect of the calibration period on self-interference channel estimation in full-duplex radio transceivers. In particular, we consider a scenario where channel estimation must be performed without a separate calibration period, which means that the received signal of interest will act as additional noise from the estimation perspective. We will explicitly analyze its effect, and quantify the increase in parameter estimation variance, or sample size, if similar channel estimation accuracy 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.

TA8a1-6
MIMO Nullforming with RVQ Limited Feedback and Channel Estimation Errors
D. Richard Brown III, Worcester Polytechnic Institute, United States; David Love, Purdue University, United States

This paper explores limited feedback nullforming techniques based on random vector quantization (RVQ) with and without receiver coordination. The availability of receiver coordination affects the type and amount of feedback required to select an appropriate precoding vector. Approximate upper and lower bounds are developed for the mean received power at primary receivers with and without receiver coordination. Numerical results show that the performance of RVQ nullforming can approach the lower bound for moderate codebook sizes if the number of primary receivers is small and/or if the variance of the channel estimation errors is not too small.

TA8a1-7
Limited Feedback in OFDM Systems for Combating ISI/ICI Caused by Insufficient Cyclic Prefix Length
Erich Zoechmann, Stefan Pratschner, Stefan Schwarz, Markus Rupp, Vienna University of Technology, Austria

In 3GPP LTE communication systems, channel state information is fed back by means of the channel quality indicator, the precoding matrix index and the rank indicator. This limited feedback information is used to adapt the transmission scheme such as to improve the throughput and to reach a certain block error rate target. We follow a common opinion from literature and use the channel impulse response to calculate the interference power caused by insufficient cyclic prefix length. By accounting for this inter symbol and inter carrier interference power in the feedback calculation, we obtain an improved throughput in MIMO OFDM systems.

TA8a1-8
Frugal Channel Tracking for Transmit Beamforming
Omar Mehanna, Nicholas Sidiropoulos, University of Minnesota, United States

Channel state feedback is a serious burden for transmit beamforming systems with many antennas in FDD mode. Instead of estimating the channel at the receiver and feeding back quantized beamformer information, a different approach that exploits the spatio-temporal correlation of the channel is proposed. The transmitter periodically sends a beamformed pilot signal, while the receiver feeds back the quantized innovation derived from either a Kalman filtering or a MAP tracking loop. Simulations show that close to optimum performance can be attained with only 2 bits per channel dwell, clearing a hurdle for transmit beamforming with many antennas in FDD mode.

Session: TAa8 – Image Processing I 8:15 AM–9:55 AM

Chair: ***Kenneth Jenkins,*** *Pennsylvania State University*

TA8a2-1

Second Order Model Deviations of Local Gabor Features for Texture Classification

David Picard, Inbar Fijalkow, ETIS - UMR 8051 / ENSEA, Université Cergy-Pontoise, CNRS, France

In this paper, we tackle the problem of texture classification with a local approach based on measuring second order deviations with respect to a dictionary of characteristic patterns. At each pixel, we extract local signal properties thanks to several Gabor filters that are aggregated on a small support region. Then, we compute a dictionary of such features that serves as a universal model. The texture signature is the deviation of second order statistics between its local features and the universal model. Experiments are made on two sets of photographic paper textures, and show the soundness of the approach.

TA8a2-2

Weighted Boundary Matching Error Concealment for HEVC Using Block Partition Decisions

Yan-Tsung Peng, Pamela Cosman, University of California, San Diego, United States

We propose a weighted boundary matching error concealment method for HEVC. It uses block partition decisions to improve a common block matching algorithm that finds blocks with the best matched boundaries from the previous frame to conceal the currently corrupted blocks. The block partition decisions from the co-located block of the corrupted one are exploited. For each partition, a summed boundary weight is computed; the one with the highest weight is chosen to be concealed next. Experimental results show the proposed method performs better than conventional error concealment methods objectively and subjectively.

TA8a2-3

Reducing the Latency and Improving the Resolution of Vector Quantization with Anamorphic Stretch Transform

Haochen Yuan, Mohammad H. Asghari, Bahram Jalali, University of California, Los Angeles, United States

Application of the recently introduced Discrete Anamorphic Stretch Transform to data clustering is proposed and demonstrated. We show that the Transform enhances vector quantization in terms of its computation speed and peak SNR by increasing the image coherence. To validate our technique's utility in data compression, we show superior performance compared to JPEG 2000.

TA8a2-4

Supervised Facial Recognition based on Multiresolution Analysis with Radon Transform

Ahmed Aldhahab, George Atia, Wasfy Mikhael, University of Central Florida, United States

A new supervised facial recognition system based on the integration of Two Dimensional Discrete Multiwavelet Transform (2D DMWT), 2D Radon Transform (2D RT), and 3D DWT is proposed. In the feature extraction step, 2D DMWT is used to extract the useful information from the image. The extracted features are then aligned using 2D RT and localized in one single band by using 3D DWT. The resulting features are fed into a Neural Network for both training and testing. The proposed algorithm is tested on different databases. It is shown that the proposed approach can significantly improve the overall performance.

TA8a2-5

On Compensating Unknown Pixel Behaviors for Image Sensors with Embedded Processing

William Guicquero, Michele Benetti, Arnaud Peizerat, Antoine Dupret, Commissariat à l'énergie atomique et aux énergies alternatives, France; Pierre Vandergheynst, École Polytechnique Fédérale de Lausanne, Switzerland

In recent image sensor design a trend emerges [1]: either block-based image processing operations or Compressive Sensing (CS) [2] tend to be performed at the focal plane level. In many cases, the objective is to alleviate the limitations of analog signals, such as limited dynamic range or power consumption. Unfortunately, this processing of analog signals often introduces artifacts. This article deals with a generic method that compensates those artifacts by post processing operations. The proposed restoration algorithm is composed of a three steps loop: regularize the image, fit the model parameters describing unknown pixel behaviors and update a regularization coefficient.

TA8a2-6
Representative Selection for Big Data via Sparse Graph and Geodesic Grassmann Manifold Distance
Chinh Dang, Hayder Radha, Michigan State University, United States

This paper addresses the problem of identifying a very small subset of data points that belong to a significantly larger massive dataset (i.e., Big Data). The small number of selected data points must adequately represent and faithfully characterize the massive Big Data. We propose a novel representative selection framework by generating a l_1 norm sparse graph, Grassmann manifold distance, and Principal component centrality for a given Big-Data dataset. We validate the proposed framework onto the problem of video summarization, and compare the result with the ground truth and with some state-of-the-art related methods.

TA8a2-7
A Generic Particle Filtering Approach for Multiple Polyhedral Object Tracking in a Distributed Active Sensor Network
Benoit Fortin, Regis Lherbier, Jea-Charles Noyer, Univ. Littoral Cote d'Opale, France

This paper presents a method for multi-target tracking in a multisensor system composed of several distributed active sensors (rangefinders). The final goal is to deliver a complete reconstruction of the environment of a vehicle. The originality of this work relies on the joint exploitation of geometric invariance properties of objects avoiding any loss of optimality and on an efficient management of transitions when the objects of interest move from one field-of-view to another.

TA8a2-8
Spatial Domain Synthetic Scene Statistics
Debarati Kundu, Brian Evans, University of Texas at Austin, United States

Natural Scene Statistics (NSS) has been applied to natural images obtained through optical cameras for automated visual quality assessment. Since NSS does not need a reference image for comparison, NSS has been used to assess user quality-of-experience, such as for streaming wireless image and video content acquired by cameras. In this paper, we take an important first step in using NSS to automate visual quality assessment of synthetic images found in video games and animated movies. In particular, we analyze NSS for synthetic images in the spatial domain using mean-subtracted-contrast-normalized (MSCN) pixels and their gradients. The primary contributions of this paper are (1) creation of a publicly available ESPL Synthetic Image database, containing 221 color images, mostly in high definition resolution of 1920x1080, and (2) analysis of the statistical distributions of the MSCN coefficients (and their gradients) for synthetic images, obtained from the image intensities. We find that similar to the case for natural images, the distributions of the MSCN pixels for synthetic images can be modeled closely by Generalized Gaussian and Symmetric Alpha Stable distributions, with slightly different shape and scale parameters.

Track A – Communications Systems

Session: TAa8 – Signal Processing for Communications 8:15 AM–9:55 AM

Chair: ***Bhavya Kailkhura,*** *Syracuse University*

TA8a3-1
Energy-Efficient Secure Communications in MISO-SE Systems
Alessio Zappone, Pin-Hsun Lin, Eduard A. Jorswieck, TU Dresden, Germany

The problem of resource allocation for energy-efficient secure communications in MISO systems is investigated, wherein a malicious user tries to eavesdrop the communication between two legitimate users. The legitimate transmitter has multiple antennas, whereas the eavesdropper and the receiver have a single antenna. Unlike most papers dealing with physical layer security, the goal is not secrecy capacity maximization, but rather secrecy energy efficiency maximization, defined as the ratio between the secrecy capacity and the consumed power. The three scenarios of perfect, partial, and statistical channel state information are solved and compared.

TA8a3-2
Distinguishing BFSK from QAM and PSK by Sampling Once per Symbol
Mohammad Bari, Milos Doroslovacki, George Washington University, United States

In this paper we propose a feature to distinguish FSK from QAM and PSK modulations. The feature is based on the imaginary part of product of two consecutive signal values where every symbol is sampled only once. Conditional probability density functions of the feature given the present modulation are determined. Central limit theorem for strictly stationary m-dependent sequences is used to obtain Gaussian approximations. Then the thresholds are determined based on the minimization of total probability of misclassification. Effects of AWGN, carrier offset and non-synchronized sampling on the performance are studied. Proposed classifier is compared to the maximum likelihood classifier.

TA8a3-3
Quadratic Program Solution of Communication Links Under Jamming

Koorosh Firouzbakht, Guevara Noubir, Masoud Salehi, Northeastern University, United States

In this paper we use a game-theoretic approach to model a wireless link under jamming. Instead of a zero-sum framework, we use the bimatrix framework where it is no longer required that the sum of the players' payoffs to be zero. Hence, a much larger class of jamming problems could be modeled. Furthermore, we assume players' strategies must be chosen from some hyper-polyhedron. We prove that the NE solution of this game corresponds to the global maximum of a quadratic program. We provide an example of a jamming problem and show that the bimatrix framework can improve jammer's payoff.

TA8a3-4
An Iterative Soft Decision Based Adaptive K-best Decoder Without SNR Estimation

Mehnaz Rahman, Ehsan Rohani, Gwan Choi, Texas A&M University, United States

This paper presents an adaptive K-best multiple-input-multiple-output (MIMO) decoding algorithm. It includes the concept of iterative lattice reduction (LR)-aided minimum-mean-square-error (MMSE) extended K-best decoding, thereby reducing the computational complexity to a great extent. The method adaptively changes list size, K with respect to channel condition, considering only the ratio of first minimum distance to the second one. Hence, accurate measurement of signal-to-noise-ratio (SNR) is not required. Using the method, we obtain similar performance compared to conventional LR-aided K-best algorithm and 1.6 dB improvement against the iterative least-sphere-decoder (LSD) at bit error rate (BER) of 10^(-6).

TA8a3-5
MMSE Scaling Enhances Performance in Practical Lattice Codes

Nuwan Ferdinand, University of Oulu, Finland; Matthew Nokleby, Duke University, United States; Brian Kurkoski, Japan Advanced Institute of Science and Technology, Japan; Behnaam Aazhang, Rice University, United States

We investigate the value of MMSE scaling for practical lattice codes. For ideal lattices, MMSE scaling has been shown to be a key ingredient in achieving the capacity of the AWGN channel. We demonstrate that MMSE scaling enhances the performance, particularly at low SNR, for practical lattice codes. For example, a dimension $n=10000$ LDLC lattice exhibits approximately 0.6 dB gain when MMSE scaling is used for a rate of 1 bit/dimension. Furthermore, we provide a novel derivation of the MMSE scaling rule, showing that it emerges naturally from principles of belief propagation decoders which account for the transmit power constraint.

TA8a3-6
RLS-Based Frequency-domain DFE for Uplink SC-FDMA

Naveed Iqbal, Azzedine Zerguine, King Fahd University of Petroleum and Minerals, Saudi Arabia; Naofal Al-Dhahir, University of Texas at Dallas, United States

In this paper, we develop a low-complexity Adaptive Frequency Domain Decision Feedback Equalizer for SC-FDMA systems. Both the feedforward and feedback filters operate in the frequency-domain and are adapted using the block RLS algorithm. We also show that the RLS-based AFD-DFE not only enjoys a significant reduction in computational complexity when compared to the frequency-domain non-adaptive channel-estimate-based MMSE-DFE but its performance is also better than that of the practical MMSE DFE (with decision errors) and close to the ideal MMSE DFE (with correct decisions)

TA8a3-7
Reduced-State Cyclic Viterbi Receiver for Localized SC-FDMA Uplink System

Jeng-Kuang Hwang, Jeng-Da Li, Yu-Chang Hsu, Chuan-Shun Lin, Yuan-Ze University, Taiwan

Under the cyclic ISI channel model induced by CP-aided single-carrier transmission system, the optimum cyclic Viterbi (CV) receiver is derived, which outperforms those suboptimal frequency-domain equalizers. To further apply the CV to localized SC-FDMA system, a reduced-state CV is then devised by using decision feedback (DF) with local tentative decisions. Moreover, an all-pass prefilter (APPF) is incorporated to suppress the DF error propagation under non-minimum phase channel. The resulting CV-APPF-DF receiver is therefore merited in performance and complexity. Simulations results demonstrate the excellent performance of the full-state CV receiver, and the near optimum performance of the reduced-state CV-APPF-DF receiver.

TA8a3-8
Energy Detection Using Very Large Antenna Array Receivers
Alex Oliveras Martinez, Elisabeth De Carvalho, Petar Popovski, Gert Frølund Pedersen, Aalborg University, Denmark

We propose the use of energy detection for single stream transmission and reception by a very large number of antennas, with primary application to millimeter wave communications. The reason for applying energy detection is low complexity, cost and power efficiency. While both energy detection and millimeter wave communications are limited to short ranges due respectively to noise sensitivity and propagation attenuation, processing by a large number of receive antennas overcomes those shortcomings to provide significant reach extension. This processing is solely based on long-term statistics of the channel and noise, making it robust to user mobility and imperfect channel knowledge.

Track D – Signal Processing and Adaptive Systems
Session: TAa8 – Adaptive Filtering 8:15 AM–9:55 AM
Chair: ***Milos Doroslovacki,*** *George Washington University*

TA8a4-1
On Component-Wise Conditionally Unbiased Linear Bayesian Estimation
Mario Huemer, Oliver Lang, Johannes Kepler University Linz, Austria

The classical unbiased condition utilized e.g. by the best linear unbiased estimator (BLUE) is very stringent. By softening the ”global” unbiased condition and introducing component-wise conditional unbiased conditions instead, the number of constraints limiting the estimator’s performance can in many cases significantly be reduced. In this work we extend the findings on component-wise conditionally unbiased (CWCU) linear Bayesian estimation for linear data models investigated e.g. in [1]. We discuss the requirements on the parameter vector, that allow for finding CWCU linear estimators outperforming the BLUE in Bayesian measures, and we derive the CWCU linear minimum mean square error (LMMSE) estimator under these conditions. In depth comparisons to the BLUE and the LMMSE estimator are followed by a well known channel estimation application which impressively demonstrates the advantages of the CWCU LMMSE estimator over the BLUE.

TA8a4-2
Performance of Proportionate-type NLMS Algorithm with Gain Allocation Proportional to the Mean Square Weight Deviation
Kevin Wagner, Naval Research Laboratory, United States; Milos Doroslovacki, George Washington University, United States

The complex colored water-filling algorithm for gain allocation has been shown to provide improved mean square error convergence performance, relative to standard complex proportionate-type normalized least mean square algorithms. This algorithm requires sorting operations and matrix multiplication on the order of the size of the impulse response at each iteration. In this paper, the mean square weight deviation and two suboptimal gain allocation algorithms are presented. They are motivated by similar algorithms introduced before for real-valued signals and systems. The presented algorithms no longer require sorting. It is shown that they provide significant computational complexity savings while maintaining comparable mean square error convergence performance. The algorithms are also investigated in the case of unknown input correlation matrix and speech input signals.

TA8a4-4
An Efficient Least Mean Squares Algorithm based on q-Gradient
Ubaid Al-Saggaf, Mohammad Moinuddin, King Abdulaziz University, Saudi Arabia; Azzedine Zerguine, King Fahd University of Petroleum and Minerals, Saudi Arabia

In this work, we propose a novel LMS type algorithm by utilizing the q-gradient concept which is derived from the definition of Jacksons derivative. The q-gradient-based LMS algorithm results in faster convergence for $q > 1$ because of the fact that the q-derivative, unlike the conventional derivative which evaluates tangent, computes the secant of the cost function and hence takes larger steps towards the optimum solution. Convergence analysis of the proposed algorithm is also presented. Simulation results are presented to support our theoretical findings.

TA8a4-5
Optimal Step Size Control for Acoustic Echo Cancellation

Khosrow Lashkari, Seth Suppappola, Cirrus Logic, United States

Depth and speed of convergence are important metrics for the performance of acoustic echo cancellers (AECs). The LMS (Least Mean Square) or NLMS (normalized LMS) algorithms constitute the core of AECs. This paper presents an optimal step size control strategy for the NLMS algorithm when the input signal is white. This strategy gives the deepest convergence in the shortest amount of time. The optimum step size turns out to be the solution of the Riccati equation. Simulation results are presented to confirm the analysis. Practical considerations for colored signals and time varying echo impulse responses are also discussed.

TA8a4-6
Stochastic Gradient Algorithm Based on an Improved Higher Order Exponentiated Error Cost Function

Umair bin Mansoor, Syed Asad, Azzedine Zerguine, King Fahd University of Petroleum and Minerals, Saudi Arabia

We propose stochastic gradient algorithm based on exponentiated cost functions that employ higher order moments of the chosen error. Recently, such algorithms based on exponential dependence of squared of the error have attracted a lot of attention. It has been felt that such algorithms have only been tested in the Gaussian noise environment. Motivated by the performance of the least-mean-fourth algorithm in sub-Gaussian environments, we make use of the same strategy to come up with a new algorithm with superior convergence and steady-state performance. Simulation shows promising results.

TA8a4-7
Spectral Multiscale Coverage with the Feature Aided CPHD Tracker

Ramona Georgescu, Shuo Zhang, Amit Surana, Alberto Speranzon, Ozgur Erdinc, United Technologies Research Center, United States

A closed loop approach for surveillance was developed leveraging the Spectral Multiscale Coverage (SMC) algorithm for sensor management coupled with the Cardinalized Probability Hypothesis Density (CPHD) multitarget tracker. Additionally, the CPHD was formulated such that it is able to ingest features, if available. Simulations with fixed and mobile sensors (the latter, tasked by the SMC) providing data to the tracker underlined the benefits of sensor fusion with respect to standard metrics of performance.

TA8a4-8
Adaptive Sampling with Sensor Selection for Target Tracking in Wireless Sensor Networks

Abdulkadir Kose, Engin Masazade, Yeditepe University, Turkey

In this paper, we consider a target tracking problem where the time interval between adjacent sensor measurements is a decision variable to be optimized. Therefore, we aim to sample the target very frequently when the uncertainty is large and sample the target less frequently when the uncertainty is small. Having obtained when to sample the target, we next determine which sensors to be selected at the intended sampling instant. Simulation results illustrate the efficiency of the proposed algorithm.

Track A – Communications Systems

Session: TAb8 – Multiuser and Cellular Systems 10:15 AM–11:55 AM

Chair: ***Rafael F. Schaefer,*** *Princeton University*

TA8b1-1
Average Sum MSE Minimization in the Multi-User Downlink With Multiple Power Constraints

Andreas Gründinger, Michael Joham, Technische Universität München, Germany; Jose Pablo Gonzalez Coma, Luis Castedo, University of A Coruna, Spain; Wolfgang Utschick, Technische Universität München, Germany

We consider a sum mean square error (MSE) transceiver design for the multi-user downlink with linear transmit power constraints. Since the multi-antenna transmitter has only imperfect CSI, the average sum MSE (SMSE) is minimized via an alternating optimization (AO). For fixed equalizers, the average SMSE minimizing precoders are found via an uplink-downlink SMSE duality based on Lagrangian duality. The precoder update therewith transforms to an uplink max-min average SMSE problem, i.e., an MMSE equalizer design and an outer worst-case noise search. This problem is optimally solved and strong duality is shown to holds at the optimum.

TA8b1-2

Hierarchical Precoding for Ultra-Dense Heterogeneous Networks

Lars Thiele, Martin Kurras, Fraunhofer Institute for Telecommunications Heinrich Hertz Institute, Germany

In this work, we demonstrate the limits from joint regularized zero-forcing precoding within a cluster of several macro and small-cell base stations. While studying the effects of heterogeneous power constraints in such a cluster of transmission nodes, we develop a hierarchical precoding solution which mitigates the inter-cell interference from the macro-cells caused a the users mainly served by the small-cells. Due to significantly reduced transmit power budget both, inter-small-cell interference as well as interference from small-cells caused at the macro users is of less importance and hence is not taken into account within the precoding algorithm.

TA8b1-3

Detection using Block QR Decomposition for MIMO HetNets

Robin Thomas, Raymond Knopp, Eurecom, France; Sunil (B.T.) Maharaj, University of Pretoria, South Africa

Interference management between uncoordinated eNBs and UEs is a crucial aspect of Heterogeneous Network (HetNet) deployments, especially if the interference can be exploited and suppressed at the receiver. In this paper, a novel preprocessing Block QR decomposition technique is proposed for a low complexity max-log-MAP receiver, in order to decode the dual-stream interferer in a 4×4 HetNet scenario. The authors show that for an SNR of 20 dB, the proposed receiver detection scheme has minimal mutual information loss for Gaussian signals, which would then enable analysis and validation (with LTE downlink simulations) of higher order MIMO detection schemes.

TA8b1-4

On Performance Prediction for Multiuser Detection Enabled Systems in Packet Based Asynchronous Gaussian Multiple Access Channels

Prabahan Basu, MIT Lincoln Laboratory, United States

Interference Multiple Access is a spectral sharing paradigm wherein multiuser detection capable transmitters target those occupied spectral bands where the mutual interference between the existing and infringing nodes is tolerable. Successful coexistence requires the coexistence seeking node to accurately gauge its own performance and to accommodate the existing node, assumed to lack MUD. We previously proposed a polynomially approximated score to rank candidate bands occupied by nodes employing packet based communications protocols. Here, we derive a computation of the proposed score based on more efficient closed form approximations, thus enabling its use in practical settings.

TA8b1-5

Decentralized Target Rate Optimization for MU-MIMO Leakage Based Precoding

Tim Rüegg, Marc Kuhn, Armin Wittneben, ETH Zurich, Switzerland

In this paper we propose a decentralized target rate precoding for multi-user multiple-input multiple-output downlink setups. The precoding is optimized for each link separately with respect to the transmit and leakage power. This allows to control the interference and to design the precoding flexibly with respect to energy efficiency and outage minimization. A closed form solution for the optimization is presented and thorough analysis on the interdependency of the transmit and leakage power is provided. The proposed precoding is tested in numerical simulations.

TA8b1-6

Leveraging Interference for Increasing Throughput and Reliability of Commercial Wireless Small Cells

Rachel Learned, Michael Pitaro, Matthew Ho, Massachusetts Institute of Technology, United States

This paper examines the potential of a new interference-leveraging scheme that relies upon interference mitigation and cognitive algorithms to enable a case by case in-base evaluation of interfering links and, as appropriate, to recognize and leverage occupied bands as opportunities for reliable communication. Simulation based analysis of achievable throughput and dropped call rates for three contending solutions are provided. Preliminary results indicate cognitive interference leveraging to be unique in its ability to provide continuous and high quality of service for both small cell and macro cell links without overt coordination with macro or other small cell bases.

TA8b1-7

Throughput Analysis of LTE and WiFi in Unlicensed Band

Abhijeet Bhorkar, Christian Ibars Casas, Pingping Zong, Intel Corporation, United States

In this paper, the co-channel performance of large scale deployment of LTE in Unlicensed (LTE-U) band and WiFi is studied using the stochastic geometry. Analytical expressions of LTE-U throughput in presence of WiFi are presented and are partly validated by the simulation results. The LTE-U Low Power Nodes (LPNs) are deployed as Poisson Point Process (PPP), while, the WiFi transmissions are modeled as hardcore Mat´ ern point process. Using this analytical approach the impact of various parameters such as sensing threshold and transmission power on the co-existence of LTE-U and WiFi is studied.

TA8b1-8

Multi-User Detection for xDSL with Partial Cooperation Among Multiple Operators

Syed Hassan Raza Naqvi, Umberto Spagnolini, Politecnico di Milano, Italy

Cross-talk (FEXT) is the most limiting factor in xDSL systems. When multiple CPEs share the same cable-binder, the inter-operator FEXT cannot be controlled or mitigates. We propose a cooperative method for inter-operator FEXT mitigation where different operators mutually cooperate without sharing any sensitive information, but rather by exchanging only their mutual interference. The iterative method based on the exchange the alien-FEXT largely improves the intra-operator MMSE multiuser detection. The performances of this interference-only exchange are comparable with fully cooperative approach where all operators fully share all the available data.

Track G – Architecture and Implementation

Session: TAb8 – Computer Arithmetic II 10:15 AM–11:55 AM

Chair: ***Sardar Muhammad Sulaman,*** *Lund University*

TA8b2-1

Improved Non-restoring Square Root Algorithm with Dual Path Calculation

Kihwan Jun, Earl Swartzlander, University of Texas at Austin, Republic of Korea

This paper focuses on reducing the delay of the non-restoring square root algorithm. Although the non-restoring square root algorithm is the fastest of the other radix-2 digit recurrent square root algorithms, there are still some possibilities to enhance its performance. To improve its performance, two new approaches are proposed here. For the first proposed approach, a novel method to find a square root bit for every iteration, which hides the total delay of the multiplexer with dual path calculation is presented. Secondly, a new method uses the modified Most Significant Carry (MSC) generator, which determines the sign of each remainder faster than a carry lookahead adder, which reduces the total delay.

TA8b2-2

Merged Residue Number System Generation

Michael Sullivan, Earl Swartzlander, University of Texas at Austin, United States

Residue number system (RNS) implementations often restrict themselves to specialized moduli sets that are chosen for efficient logic synthesis. Despite the paramount importance of implementation efficiency using these specialized moduli sets, such RNS implementations typically use separate conversion logic for the generation of each RNS modulus. This paper considers a novel parallel residue generation procedure for moderate dynamic range RNS numbers. This procedure shares the majority of logic between selected moduli, greatly increasing efficiency over existing forward conversion schemes.

TA8b2-3

Partial Product Generation and Addition for Multiplication in FPGAs With 6-Input LUTs

George Walters, Penn State Erie, The Behrend College, United States

Multiplication is the dominant operation for many applications implemented on field-programmable gate arrays (FPGAs). Although most current FPGA families have embedded hard multipliers, soft multipliers using lookup tables (LUTs) remain important. This paper presents novel circuits for partial product generation and addition and their usage in two’s complement multipliers. Synthesis results for Virtex-7 are presented. Proposed single-cycle multipliers use 35% to 45% fewer LUTs and have 9% to 22% less delay than the best alternatives. Proposed pipelined multipliers use 32% to 40% fewer LUTs than LogiCORE IP multipliers and can be clocked 29% to 42% faster than embedded hard multipliers.

TA8b2-4
Low-Power Radix-4 Quotient Generator
Milos Ercegovac, University of California, Los Angeles, United States

A low-power radix-4 quotient generator is presented. A modified digit-recurrence division algorithm is used to produce only quotient without final remainder. A gradual bit-slice deactivation is exploited to reduce the number of active modules across iterations and, consequently, to reduce power dissipation and energy. In this paper we report the synthesis results of radix-4 quotient generators for 16, 24, 32, and 54 bits with respect to area, delay, power dissipation, and energy. We compare these results with the corresponding results of radix-4 SRT dividers for the same precisions.

TA8b2-5
Memristor Based Adders
Divya Mahajan, Matheen Musaddiq, Earl Swartzlander, University of Texas at Austin, United States

Currently memristors are being researched to offer logic and memory functions. Recently, ultra dense resistive memory arrays built from various two terminal semiconductor or insulator thin film devices have been demonstrated [1]. This paper presents memristor-based design of commonly used (ripple carry, conditional sum and parallel prefix) adders. The latency and area of these adders are compared.

TA8b2-6
Canonic Real-Valued FFT Structures
Megha Parhi, Yingjie Lao, Keshab K. Parhi, University of Minnesota, Twin Cities, United States

This paper, for the first time, presents novel DIT and DIF structures for computing real FFT, referred as RFFT, that are canonic with respect to the number signal values computed at each FFT stage. In the proposed structure, in an N-point RFFT, exactly N signal values are computed at the output of each FFT stage and at the output. While canonic FFT structures based on decimation-in-frequency were presented before, these structures were derived in an adhoc way. This paper presents a formal method to derive canonic DIF RFFT structures. Examples of canonic structures for non-power-of-two size RFFT are also presented.

TA8b2-7
A High Throughput and Low Power Radix-4 FFT Architecture
Soumak Mookherjee, Linda S. DeBrunner, Victor DeBrunner, Florida State University, United States

An FTT architecture is proposed that is suitable for both high performance and low power applications. The architecture is based on a Radix-4 algorithm using pipelined Multi-path Delay Commutators. Two separate datapaths are used so that the hardware can process eight inputs in parallel. The throughput is increased by a factor of eight while achieving 100% hardware utilization. Power consumption of this architecture is approximately 75% less than the Radix-4 MDC structure with the same throughput. Using a Xilinx FPGA Virtex 5, only slightly more than twice the area is required for eight times higher throughput for a 256-point FFT.

TA8b2-8
A Domain Splitting Algorithm for the Mathematical Functions Code Generator
Olga Kupriianova, Christoph Lauter, UPMC, LIP6, PEQUAN team, France

The general approach to mathematical function implementation consists of three stages: range reduction, approximation and reconstruction. The range reduction step is needed to reduce the degree of the approximation polynomial and to simplify the error analysis. For some particular functions (e.g. exp) it is done using its algebraic properties. In general case the whole domain is split into small subdomains to get low-degree approximation on each of them. Here we present a novel algorithm for the domain splitting that will be integrated soon to Metalibm code generator.

Track E – Array Signal Processing

Session: TAb8 – Array Processing Methods 10:15 AM–11:55 AM

Chair: ***Piya Pal,*** *University of Maryland*

TA8b3-1

Array Self Calibration with Large Initial Errors

Benjamin Friedlander, University of California, Santa Cruz, United States

A self-calibration algorithm is presented for direction finding in the presence of unknown complex sensor gains. The method jointly estimates the directions of arrival of all the sources as well as the unknown gains. Existing self-calibration techniques are iterative and require sufficiently good initial estimates in order to converge to a correct solution. These techniques are ineffective in the presence of initially large calibration errors which make it impossible to reliably initialize the algorithm. The method presented here is non-iterative, does not require initialization, and handles large sensor gain errors. The performance of the algorithm is illustrated by numerical examples.

TA8b3-2

Maximum Likelihood Estimation for Geolocation in the Presence of Multipath

Benjamin Friedlander, University of California, Santa Cruz, United States

We consider the problem of estimating the location of an emitter in a multipath environment from measurements by multiple widely spaced sensors. We present a maximum likelihood approach for estimating the emitter position jointly with the positions of the reflectors, the unknown complex gains of the propagation paths, and the unknown transmitted signal. This approach provides unbiased emitter position estimates whether or not there is a direct line of sight. A variation of the Expectation-Maximization (EM) algorithm is used to provide an iterative, computationally feasible calculation of the maximum- likelihood location estimate.

TA8b3-3

Enhanced Location Detection Algorithms Based on Time of Arrival Trilateration

Sajina Pradhan, Jae-young Pyun, Goo-Rak Kwon, Seokjoo Shin, Suk-seung Hwang, Chosun University, Republic of Korea

The TOA trilateration method decides the location of MS using an intersection point of three circles with centers corresponding three BS coordinates and radius based on the distance between MS and three BSs. Since the distance between BS and MS is generally estimated counting the number of time delay samples, the estimated distances are slightly increased and three circles may not intersect at a point. In this paper, we introduce the shortest distance and line intersection algorithms for improving conventional TOA trilateration method to resolve above problem. Also, the mathematic analysis is provided to indicate the relation between both algorithms.

TA8b3-4

Designing Radio Interferometric Positioning Systems for Indoor Localizations in Millimeter Wave Bands

Marie Shinotsuka, Georgia Institute of Technology, United States; Yiyin Wang, Shanghai Jiao Tong University, China; Xiaoli Ma, G. Tong Zhou, Georgia Institute of Technology, United States

Taking advantage of the spectrum characteristics of MMW bands, the indoor localization system using the radio interferometric positioning system (RIPS) employing space-time coding is proposed in this paper. The space-time RIPS (STRIPS) is the enhancement of the RIPS to work in MMW bands under the flat-fading channel. Two anchor nodes simultaneously transmit at two time slots with different frequencies, and the target node samples the signal at the low-sampling frequency. The STRIPS achieves the range-difference (RD) estimate without approximation, is immune to channel fading effects, and accommodates the frequency offsets. The performance of the STRIPS is confirmed by Monte-Carlo simulations.

TA8b3-5

Indoor Sound Source Localization and Number Estimation Using Infinite Gaussian Mixture Model

Longji Sun, Qi Cheng, Oklahoma State University, United States

This paper deals with sound source number estimation and localization problem in indoor environments using a circular microphone array. The problem is approached in the time-frequency (TF) domain by performing a single source localization algorithm at selected TF points and consequently generating one direction of arrival (DOA) estimate at each of the points.

The resulted DOA estimates are assumed from an infinite Gaussian mixture model. The number and the means of Gaussian components correspond to the number and the true DOAs of the sources, respectively. The proposed algorithm is tested using real experiments.

TA8b3-6

On the Structural Nature of Cooperation in Distributed Network Localization

Alireza Ghods, Stefano Severi, Giuseppe Abreu, Jacobs University Bremen, Germany; Samuel Van de Velde, Ghent University, Belgium

We demonstrate analytically that the contribution of cooperation in improving the accuracy of network localization has a fundamentally structural nature, rather then statistical as widely believed. The New approach to build Fisher Information Matrices offers new insight onto the structure of FIMs, enabling us to easily account for both anchor and node location uncertainties. Surprisingly, it is found that in the presence of node location uncertainty and regardless of ranging error variances, the key contribution of cooperation in network localization is not to add statistical node-to-node information, but rather to provide a structure over which node-to-anchor information is better exploited.

TA8b3-7

Enabling Distributed Detection with Dependent Sensors

Brian Proulx, Junshan Zhang, Douglas Cochran, Arizona State University, United States

Performing distributed detection with a large number of sensors that have correlated measurements is not computationally feasible at the fusion center. Even storing the probability distributions of the measurements necessary to decide between competing hypotheses is intractable for even a moderate number of remote sensors when the measurements are correlated. We propose utilizing the t-cherry junction tree, an approach from probabilistic graphical models, to approximate the distribution of the measurements. This approach allows for a compact representation of the distributions while maintaining a good approximation to the true distribution. The performance of the approach is demonstrated via simulations.

TA8b3-8

Active Sonar Transmission Strategies in the Presence of Strong Direct Blast

Luzhou Xu, Jian Li, Akshay Jain, University of Florida, United States

In this paper, with the help of in-water experimentation data, we study: (1) the merits and limitations of two major classes of Active Sonar Systems, namely, Pulse Active Sonar (PAS) and Continuous Active Sonar (CAS), with the Doppler-Tolerant Linear Frequency Modulation (LFM) waveform; and (2) the merits and limitations of Doppler-Tolerant LFM and the Doppler- Sensitive SHAPE waveforms with CAS. Throughout the study, Matched Filter (MF) is used as the receiver design. The strong delay and Doppler spread direct blast and poor MF performance in noisy environments warrant us to introduce processing techniques which enable receivers to produce accurate range estimates.

Track D – Signal Processing and Adaptive Systems

Session: TAb8 – Compressed Sensing III 10:15 AM–11:55 AM

Chair: ***Victor DeBrunner,*** *Florida State University*

TA8b4-1

Super-resolution Line Spectrum Estimation with Block Priors

Kumar Vijay Mishra, Myung Cho, Anton Kruger, Weiyu Xu, University of Iowa, United States

We address the problem of super-resolution line spectrum estimation of an undersampled signal with block prior information. The component frequencies of the signal are assumed to take arbitrary continuous values in known frequency blocks. We formulate a general semidefinite program to recover these continuous-valued frequencies using theories of positive trigonometric polynomials. The proposed semidefinite program achieves super-resolution frequency recovery by taking advantage of known structures of frequency blocks. Numerical experiments show great performance enhancements using our method.

TA8b4-3

Complexity Reduction in Compressive Sensing using Hirschman Uncertainty Structured Random Matrices

Peng Xi, Victor DeBrunner, Florida State University, United States

Compressive Sensing (CS) increases the computational complexity of decoding while simplifying the sampling process. In this paper, we apply our previously discussed Hirschman Optimal Transform to develop a series of sensing matrices that reduce the computational complexity of decoding while preserving the recovery performance. In addition, this application provides us alternative choices when we need different accuracy levels for the recovered image. Our simulation results show that with only 1/4 the computational resources of the partial DFT sensing basis, our proposed new sensing matrices achieve the best PSNR performance, which is fully 5dB superior to other commonly used sensing bases.

TA8b4-4

A Sparse Approach for Estimation of Amplitude Modulated Sinusoids

Stefan Ingi Adalbjörnsson, Johan Swärd, Andreas Jakobsson, Ted Kronvall, Lund University, Sweden

We consider the problem of spectral analysis of signals composed of sums of multiple amplitude modulated, possibly harmonically related, sinusoids using a sparse approach. By separating the nonlinear frequency variables using a dictionary of possible frequency components as well as a spline basis for the amplitude modulation, results in a convex criterion which can be efficiently solved without worrisome local minima. The resulting method makes no model order assumption and automatically estimates both the signal parameters and their amplitude modulations.

TA8b4-5

Sparsity Order Estimation for Single Snapshot Compressed Sensing

Florian Roemer, Anastasia Lavrenko, Giovanni Del Galdo, Thomas Hotz, Technische Universitaet Ilmenau, Germany; Orhan Arikan, Bilkent University, Turkey; Reiner Thomae, Technische Universitaet Ilmenau, Germany

In this paper we discuss the estimation of the sparsity order for a Compressed Sensing scenario where only a single snapshot is available. We demonstrate that a specific design of the sensing matrix enables us to transform this problem into the estimation of a matrix rank in the presence of additive noise. Thereby, we can apply existing model order selection algorithms to determine the sparsity order. We also argue that the proposed sensing matrix design may have benefits that go beyond the estimation of the sparsity both for the measurement as well as for the reconstruction strategy.

TA8b4-6

Streaming Signal Recovery Using Sparse Bayesian Learning

Uditha Wijewardhana, Marian Codreanu, Centre for Wireless Communications, Finland

We consider the recursive reconstruction of a streaming signal from compressive measurements. We reconstruct the streaming signal over shifting intervals using a recovery method based on sparse Bayesian learning. The proposed method use the support of the previously reconstructed estimate to provide a warm-start to the recovery algorithm, which improves the accuracy and the speed of the signal estimates.

TA8b4-7

Compressed Change Detection for Structural Health Monitoring

Omid Sarayanibafghi, George Atia, Masoud Malekzadeh, Necati Catbas, University of Central Florida, United States

The problem of detection of a sparse number of damages in a structure is considered. The idea relies on the newly developed framework for compressed change detection, which leverages the unique covering property of identifying codes to detect statistical changes in stochastic phenomena. Since only a small number of damage scenarios can occur simultaneously, change detection is applied to responses of pairs of sensors that form an identifying code over a learned damage-sensing graph. An asymptotic analysis of the detection delay and the probability of detection of the proposed approach is provided when the number of damage scenarios is large.

TA8b4-8

A Sparse Semi-Parametric Chirp Estimator

Johan Swärd, Johan Brynolfsson, Andreas Jakobsson, Maria Hansson-Sandsten, Lund University, Sweden

We introduce a dictionary learning approach for estimating linear chips. A dictionary is created from a set of possible starting frequency points and rates, and the estimates are then found by minimizing the distance between the signal and the dictionary components together with an ℓ_1-norm penalty which enforces sparsity. In typical solutions, one is forced to include a vast number of dictionary elements in order to enable high resolution estimates, which frequently leads to a computationally cumbersome optimization. Herein, we divide the coupled estimation of the starting frequency and the rate into two optimization problems, thereby lowering the computational complexity.

Track D – Signal Processing and Adaptive Systems

Session: TPa1 – Covariance Mining

Chair: ***Pradeep Ravikumar,*** *University of Texas at Austin*

TP1a-1 1:30 PM

Abstract Algebraic-Geometric Subspace Clustering

Manolis Tsakiris, Rene Vidal, Johns Hopkins University, United States

We consider an abstract version of the subspace clustering problem, where one is given the algebraic variety of a union of subspaces, and the goal is to decompose it into the constituent subspaces. We propose a provably correct algorithm for addressing the general case of unknown number of subspaces of unknown and possibly different dimensions. Using gradients of vanishing polynomials at a point, the algorithm intersects the variety with a chain of hyperplanes until the subspace containing the point is identified. By repeating this procedure for other points, our algorithm eventually identifies all the subspaces and their dimensions.

TP1a-2 1:55 PM

Minimum Variance Portfolio Optimization with Robust Shrinkage Covariance Estimation

Liusha Yang, Hong Kong University of Science and Technology, Hong Kong SAR of China; Romain Couillet, Supelec, France; Matthew McKay, Hong Kong University of Science and Technology, Hong Kong SAR of China

This paper aims at designing a novel covariance estimation technique for optimizing large portfolios in the presence of heavy-tailed data or outliers, and under practical conditions in which the number of observed samples is of similar order to the number of assets in the portfolio. This covariance estimation approach is based on the shrinkage Tyler's robust M-estimator with risk-minimizing shrinkage parameter. Our portfolio optimization method is shown via simulations to outperform existing methods both for synthetic data and for real historical stock returns from the Hang Seng Index.

TP1a-3 2:20 PM

Greedy Algorithms in Convex Optimization on Banach Spaces

Vladimir Temlyakov, University of South Carolina, United States

Greedy algorithms which use only function evaluations are applied to convex optimization in a general Banach space X. Along with algorithms that use exact evaluations, algorithms with approximate evaluations are treated. A priori upper bounds for the convergence rate of the proposed algorithms are given. These bounds depend on the smoothness of the objective function and the sparsity or compressibility (with respect to a given dictionary) of a point in X where the minimum is attained.

TP1a-4 2:45 PM

Greedy Algorithms for Learning Graphical Models

Ali Jalali, Christopher Johnson, Pradeep Ravikumar, University of Texas at Austin, United States

Undirected graphical models, also known as Markov random fields, are widely used in a variety of domains. Recovering their underlying Markov conditional independence graph structure is important for many of the applications of MRFs. Here, we revisit a classical greedy algorithm, that iteratively adds and deletes edges, and show that when these forward and backward steps are performed appropriately, we surprisingly obtain a state of the art method, that not only has computational advantages over regularized convex optimization based approaches, but is also sparsistent, or consistent in sparsity pattern recovery, under weaker conditions, and with a smaller sample complexity.

Session: TPb1 – Large-Scale Learning and Optimization

Chair: ***Alejandro Ribeiro,*** *University of Pennsylvania*

TP1b-1 3:30 PM

Distributed Adaptive Sparsity-Imposing Canonical Correlations

Jia Chen, Ioannis Schizas, University of Texas at Arlington, United States

The problem of tracking sensor clusters acquiring information for time-varying sources which are sensed via nonlinear data models is considered. Canonical correlation analysis (CCA) is integrated with norm-one regularization along with exponential weighing to adaptively process the acquired data. This leads to a framework that has the potential to adaptively cluster the sensors based on their source information content which may be varying with time. A separable formulation is derived which then is tackled using coordinate descent techniques to derive a sensor clustering scheme that processes data online and employs sparsity to carry out the clustering.

TP1b-2 3:55 PM

Game-Theoretic Learning In A Distributed-Information Setting: Distributed Convergence To Mean-Centric Equilibria

Brian Swenson, Soummya Kar, Carnegie Mellon University, United States; Joao Xavier, Instituto Superior Tecnico, Portugal

The paper considers distributed learning in large-scale games via fictitious-play type algorithms. Given a preassigned communication graph structure for information exchange among the players, this paper studies a distributed implementation of the Empirical Centroid Fictitious Play (ECFP) algorithm that is well-suited to large-scale games in terms of complexity and memory requirements. It is shown that the distributed algorithm converges to an equilibrium set denoted as the mean-centric equilibria (MCE) for a reasonably large class of games.

TP1b-3 4:20 PM

Network Newton

Aryan Mokhtari, Alejandro Ribeiro, University of Pennsylvania, United States

We study the problem of minimizing a sum of convex objective functions where the components of the objective are available at different nodes of a network. We propose a decentralized network Newton (NN) method that achieves faster convergence than distributed gradient methods. Similar to the latter, NN solves a surrogate problem that is an approximate version of the original. The surrogate problem can be efficiently solved using an inexact Newton method that uses an approximation to the Newton in a decentralized manner. Theoretical analysis of NN shows a superlinear rate of convergence to a neighborhood of the optimal solution.

TP1b-4 4:45 PM

Communication-Computation Tradeoffs in Decentralized Stochastic Optimization

Konstantinos Tsianos, Michael Rabbat, McGill University, Canada

We study dual averaging algorithms for decentralized stochastic optimization. The aim of the network is to minimize a convex objective. Each node has access to a stochastic first-order oracle which provides noisy observations of the objective function gradient at a query point. Existing theory focuses on how the optimization error decays as a function of the number of oracle queries. In this paper we consider the tradeoff between computation and communication, noting that communication is often significantly more time-consuming than computation when solving big-data problems over a compute cluster.

Session: TPa2 – Bioinformatics and DNA Computing

Co-Chairs: ***Olgica Milenkovic,*** *University of Illinois at Urbana-Champaign* ***and Farzad Farnoud,*** *California Institute of Technology*

TP2a-1 1:30 PM

On the Capacity of String-Duplication Systems and Genomic Duplication

Farzad Farnoud, California Institute of Technology, United States; Moshe Schwartz, Ben-Gurion University of the Negev, Israel; Jehoshua Bruck, California Institute of Technology, United States

It is known that the majority of the human genome consists of repeated sequences. Furthermore, it is believed that a significant part of the rest of the genome also originated from repeated sequences and has mutated to its current form. We investigate the possibility of constructing an exponentially large number of sequences from a short initial sequence and simple duplication rules, including those resembling genomic duplication processes. Our results include the exact capacities, and bounds on the capacities, of four fundamental string-duplication systems.

TP2a-2 1:55 PM

Intrinsic Universality and the Computational Power of Self-Assembly

Damien Woods, California Institute of Technology, United States

One of the goals of the theory of molecular programming is to study systems composed of tiny molecules that interact together to form complicated structures and carry out sophisticated dynamics, and in particular to characterize the abilities and limitations of such systems. The talk will introduce some of the concepts in the field with a focus on the topic of algorithmic self-assembly. Here the idea is to design small sets of interacting square tiles, that stick together in very specific ways to form larger structures. Tiles bind in a way that can be considered as carrying out a computation, similar to what is seen in cellular automata and Wang tiling. This allows for the fabrication of complicated shapes and patterns in a bottom-up fashion. A number of theoretical self-assembly models have been studied with a variety of results characterizing their abilities. We will discuss the use of simulation as a tool to compare these models, and indeed to classify and separate their computational and expressive power. Our journey begins with the result that there is a single intrinsically universal tile set, that with proper initialization and scaling, simulates any tile assembly system. This intrinsically universal tile set exhibits something stronger than Turing universality: it directly simulates the geometry and dynamics of any simulated system. From there we find that there is no such tile set in the noncooperative, or temperature 1, model, proving it weaker than the full tile assembly model. In the two-handed or hierarchical model, where large assemblies can bind together in one step, we encounter an infinite set, of infinite hierarchies, with strictly increasing simulation power. Towards the end of our adventure, we find one tile to rule them all: a single rotatable, flipable, polygonal tile that can simulate any tile assembly system. It seems this could be the beginning of a much longer journey, so directions for future work are suggested.

TP2a-3 2:20 PM

Hybrid Rank Aggregation for Gene Prioritization

Minji Kim, Farzad Farnoud, Olgica Milenkovic, University of Illinois at Urbana-Champaign, United States

Gene prioritization refers to a family of computational techniques used to infer disease genes through a set of training genes and carefully chosen similarity criteria. Test genes are scored based on their average similarity to the training set, and the rankings of genes under various similarity criteria are aggregated (fused) via statistical methods. The contributions of our work are threefold: a) first, we investigate the predictive quality of a number of aggregation methods known from machine learning and social choice theory; b) second, guided by the findings of the first stage of testing, we propose a new approach to genomic data fusion, termed hybrid rank aggregation, which extracts the advantages of score-based and combinatorial aggregation techniques; c) third, we propose an iterative procedure for gene discovery that operates via successful augmentation of the set of training genes by genes discovered in previous rounds of testing and checked for consistency. We test our methods on a number of disease datasets, including breast cancer, colorectal cancer, ischemic stroke, autism and others, and perform inference on new glioblastoma-related genes. Our methods are conceptually simple and, in many instances, outperform state-of-the-art software tools such as ToppGene and Endeavour.

TP2a-4 2:45 PM

Rate-Independent Computation in Chemical Reaction Networks

David Doty, California Institute of Technology, United States

We study the following problem: what functions f:R^k --> R can be computed by a chemical reaction network that eventually produces the correct amount of the "output" molecule, no matter the rate at which reactions proceed? Such a network is correct whether its evolution is governed by the standard model of mass-action kinetics or alternatives such as Hill-function or Michaelis-Menten kinetics. We prove that f is computable in this manner if and only if it is *continuous and piecewise linear*.

Track H – Speech, Image and Video Processing

Session: TPb2 – Echo Cancellation

Chair: ***Steven Grant,*** *Missouri University of Science and Technology*

TP2b-1 3:30 PM

Echo Cancellation for Bone Conduction Transducers

Mohammad Behgam, Steven L. Grant, Missouri University of Science and Technology, United States

Bone conduction transducers are attractive for challenging acoustic environments. Bone vibrators (BVs) allow users to leave their ears open, enhancing situational awareness. Bone conduction microphones (BCMs) increase transmitted SNR because they are insensitive to air-conducted sound. In full-duplex mode, coupling between BVs and BCMs results in annoying echo. The echo path's linearity, stationarity, and length all affect the feasibility building an echo canceller. This paper describes those properties and describes a proposed echo canceller design.

TP2b-2 3:55 PM

Uncertainty Modeling in Acoustic Echo Control

Gerald Enzner, Rainer Martin, Ruhr-University Bochum, Germany; Peter Vary, RWTH Aachen University, Germany

Acoustic echo control (AEC) is a crucial component of hands-free voice interfaces. For sufficient echo suppression, the acoustic echo canceler needs to be complemented by an adaptive echo suppression postfilter. Based on a stochastic echo path model, this contribution derives an MMSE solution for echo canceler and postfilter jointly. The resulting postfilter utilizes the deterministic far-end signal and employs the undermodeling error and uncertainty of the acoustic echo path in its gain computation. It thus compensates typical deficiencies of acoustic echo cancelers in real-world applications. Another implication lies in the deep justification of the recent Kalman filtering trend in AEC.

TP2b-3 4:20 PM

A Kalman Filter for Stereophonic Acoustic Echo Cancellation

Constantin Paleologu, University Politehnica of Bucharest, Romania; Jacob Benesty, University of Quebec, Canada; Steven L. Grant, Missouri University of Science and Technology, United States; Silviu Ciochina, University Politehnica of Bucharest, Romania

The stereophonic acoustic echo cancellation (SAEC) scheme was recently recast by using the widely linear (WL) model, i.e., as a single-input/single-output system with complex random variables. In this paper, we present a Kalman filter with individual control factors (ICF-KF) in the context of the WL model for SAEC. As a specific feature, this algorithm uses a different level of uncertainty for each coefficient of the filter. Simulation results indicate that the ICF-KF outperforms the recursive least-squares (RLS) algorithm, which is usually considered as the benchmark for SAEC.

TP2b-4 4:45 PM

Study and Design of Differential Microphone Array Beamforming

Jingdong Chen, Northwestern Polytechnical University, China; Jacob Benesty, INRS-EMT, University of Quebec, Canada

Differential microphone arrays (DMAs), a particular kind of sensor arrays that are responsive to the differential sound pressure field, have a broad range of applications in sound recording, noise reduction, signal separation, dereverberation,etc. Traditionally, an Nth-order DMA is formed by combining, in a linear manner, the outputs of a number of DMAs up to (including) the order of N-1. This method, though simple and easy to implement, suffers from a number of drawbacks and limitations that prevent DMAs from being widely deployed. This paper presents a new approach to the design of linear DMAs. The proposed technique converts the DMA beamforming design to simple linear systems to solve. It is shown that this approach is much more flexible as

compared to the traditional methods in the design of different directivity patterns. Some methods are also presented to deal with the white noise amplification problem, which used to be a big problem for DMAs, particularly the high-order ones, being used in practice.

Track D – Signal Processing and Adaptive Systems

Session: TPa3 – Machine Learning

Chair: ***Vassilis Kekatos,*** *University of Minnesota*

TP3a-1 1:30 PM

Consensus Inference with Multilayer Graphs for Multi-modal Data

Karthikeyan Natesan Ramamurthy, IBM T. J. Watson Research Center, United States; Jayaraman J. Thiagarajan, Lawrence Livermore National Laboratory, United States; Rahul Sridhar, Premnishanth Kothandaraman, Ramanathan Nachiappan, SSN College of Engineering, India

The increasing modalities of data generation necessitates the development of machine learning techniques that can perform efficient inference with multi-modal data. In this paper, we present an approach that can learn discriminant low-dimensional projections from supervised multi-modal data for consensus inference. We construct intra- and inter-class similarity graphs for each modality and optimize for consensus projections in the kernel space. We also provide methods for out-of-sample extensions with novel test data. Classification results with standard multi-modal data sets show that the proposed consensus approach performs better than classification using the individual modalities.

TP3a-2 1:55 PM

Energy Price Matrix Factorization

Vassilis Kekatos, University of Minnesota, United States

Statistical learning tools are applied here to study the potential risks of revealing the topology of the underlying power grid using publicly available market data. It is first recognized that the matrix of real-time locational marginal prices admits an interesting bilinear decomposition: It can be expressed as the product of a sparse, positive definite matrix with non-positive off-diagonal entries times a sparse and low rank matrix. A convex optimization problem involving sparse and low-rank regularizers is formulated to recover the constituent matrix factors. The novel scheme yielded encouraging topology recovery results on market data generated using the IEEE 14-bus grid.

TP3a-3 2:20 PM

A New Reduction Scheme for Gaussian Sum Filters

Leila Pishdad, Fabrice Labeau, McGill University, Canada

In this paper we propose a low computational complexity reduction scheme for Gaussian Sum Filters. Our method uses an initial state estimation to find the active noise clusters and removes all the others. Since the performance of our proposed method relies on the accuracy of the initial state estimation, we also propose five methods for finding this estimation. We provide simulation results showing that with suitable choice of the initial state estimation, our proposed reduction scheme provides better accuracy and precision when compared with other reduction methods.

TP3a-4 2:45 PM

Exploring Upper Bounds on the Number of Distinguishable Classes

Catherine Keller, MIT Lincoln Laboratory, United States; Gary Whipple, Laboratory for Telecommunication Sciences, United States

Information theoretic upper bounds on the number of distinguishable classes enable assessments of feasibility when applying classification techniques. A goal of this paper is to examine the behavior of these upper bounds as the items being classified becomes more complex in the sense that the number of degrees of freedom increases. We synthesize filters with different numbers of stages to represent items with varying levels of complexity. We examine the behavior of feature scatter statistics and the Fano upper bound for the number of distinguishable classes as a function of SNR, to make the comparisons.

Track D – Signal Processing and Adaptive Systems

Session: TPb3 – Sparse Signal Recovery

Co-Chairs: ***Daniel Palomar,*** *Hong Kong University of Science and Technology* ***and Gonzalo Mateos,*** *University of Rochester*

TP3b-1 3:30 PM

Compression Schemes for Time-Varying Sparse Signals

Sundeep Prabhakar Chepuri, Geert Leus, Delft University of Technology, Netherlands

In this paper, we will investigate adaptive compression schemes for time-varying sparse signals. In particularly, we focus on designing sparse compression matrices. Sparse sensing (i.e., a sparse compression matrix) leads to a decentralized compression which is important for distributed sampling, and thus minimizes the number of sensors. The compression matrices at each time step are designed based on the entire history of measurements and known dynamics. The compression matrices are determined by evaluating a function of the a posteriori error covariance, such that the selected subset of sensors minimizes the estimation error.

TP3b-2 3:55 PM

A Fast Algorithm for Sparse Generalized Eigenvalue Problem

Junxiao Song, Prabhu Babu, Daniel Palomar, Hong Kong University of Science and Technology, Hong Kong SAR of China

We consider an L0-norm penalized formulation of the generalized eigenvalue problem, aimed at extracting the leading sparse generalized eigenvector of a matrix pair. To attack the problem, we first approximate the L0-norm by a continuous surrogate function. Then an algorithm is developed via iteratively majorizing the surrogate function by a quadratic separable function, which at each iteration reduces then to a regular generalized eigenvalue problem. An efficient specialized algorithm for finding the leading generalized eigenvector is provided. Numerical experiments show that the proposed algorithm outperforms existing algorithms in terms of both computational complexity by orders of magnitude and support recovery.

TP3b-3 4:20 PM

Bootstrapped Sparse Bayesian Learning for Sparse Signal Recovery

Ritwik Giri, Bhaskar Rao, University of California, San Diego, United States

In this article, the sparse signal recovery problem is studied in a hierarchical Bayesian framework and a novel Bootstrapped Sparse Bayesian Learning method is developed. In SBL the choice of prior over the variances of the Gaussian Scale mixture has been an interesting area of research and it still remains an open and interesting question. This motivates our use of a more generalized maximum entropy density as the prior leading to a new variant of SBL. It is shown to perform better than traditional SBL empirically and also found to accelerate the convergence and make the pruning procedure more robust.

TP3b-4 4:45 PM

A Fast Proximal Gradient Algorithm for Reconstructing Nonnegative Signals with Sparse Transform Coefficients

Renliang Gu, Aleksandar Dogandžic, Iowa State University, United States

We develop a fast proximal gradient scheme for reconstructing nonnegative signals that are sparse in a transform domain from underdetermined measurements. We adopt the unconstrained regularization framework where the objective function to be minimized is a sum of a data fidelity (negative log-likelihood) term and a regularization term that imposes signal nonnegativity and sparsity via an l1-norm constraint on the signal's transform coefficients. This objective function is minimized via Nesterov's proximal-gradient method, with the proximal mapping task solved via alternating direction method of multipliers (ADMM). In the numerical examples, we demonstrate the performance of the proposed method.

Session: TPa4 – Optical Communications

Chair: ***Philippe Ciblat,*** *TELECOM ParisTech*

TP4a-1 1:30 PM

Fifth-Order Volterra Series Based Nonlinear Equalizer for Long-Haul High Data Rate Optical Fiber Communications

Abdelkerim Amari, Philippe Ciblat, Yves Jaouen, Telecom ParisTech, France

We propose a fifth-order Inverse Volterra Series Transfer Function based nonlinearities compensation for ultra high data rate optical fiber communications using OFDM. The main contribution consists of the derivations of the corresponding fifth-order kernel. Compared to the third-order case, we significantly improve the performance in terms of BER and/or transmission distance.

TP4a-2 1:55 PM

Improving the Ultraviolet Scattering Channel Via Beam Reshaping

Difan Zou, Shang-Bin Li, Zhengyuan Xu, School of Information Science and Technology, and Optical Wireless Communication and Network Center, China

The beam reshaping method is adopted for improving the efficiency in the non-line of sight (NLOS) ultraviolet scattering communication channel. By random scattering trajectory Monte Carlo simulation, the numerical results show the beam with rectangular or elliptical photometries has significant advantage in the received signal intensity against the circular one. The influences of the geometric configurations of both the transmitter and the receiver on the received signal intensity are discussed. The corresponding impulse responses are also analyzed.

TP4a-3 2:20 PM

Correlation Study on the SIMO Channel Output of NLOS Optical Wireless Communications

Boyang Huang, Chen Gong, Zhengyuan Xu, University of Science and Technology of China, China

The gain of single-input multiple-output (SIMO)/multiple-input multiple-output (MIMO) communication over single-input single-output (SISO) communication critically depends on the correlation on the link gain between the transmitting-receiving antenna pairs. In this work, in order to evaluate the SIMO gain of non-line of sight (NLOS) optical wireless communication, we study such link channel correlation based on the channel generated from stochastic physics. In simulations with one transmitter and two receivers, for transmitter-receiver distance 100m, the correlation is larger than 0.6 for the receiver-receiver distance up to 20m; and for transmitter-receiver distance 1000m, the correlation is larger than 0.4 for the receiver-receiver distance up to 200m.

TP4a-4 2:45 PM

An Improved Performance Decoding Technique for Asymmetrically and Symmetrically Clipped Optical (ASCO)-OFDM

Nan Wu, Yeheskel Bar-Ness, New Jersey Institute of Technology, United States

We propose an improved receiving technique for asymmetrically and symmetrically clipped optical (ASCO)-OFDM intensity modulation direct detection (IM/DD) wireless communication systems. At the receiver, the ACO-OFDM symbols can be easily obtained by extracting the data from the odd subcarriers; the SCO-OFDM symbols can be obtained by subtracting both the estimated ACO-OFDM clipping noise and the SCO-OFDM clipping noise from the even subcarriers. The symbol error rate performance of SCO-OFDM signals depends on the precision of ACO-OFDM signals. Thus, we apply an improved ACO-OFDM receiving technique in our current receiver to further improve the SER performance of the whole ASCO-OFDM signal.

Session: TPb4 – Energy Harvesting Wireless Communications

Chair: ***Sennur Ulukus,*** *University of Maryland*

TP4b-1 3:30 PM

On the Capacity of the Energy Harvesting Channel with Energy Transfer

Aylin Yener, Pennsylvania State University, United States

Energy harvesting wireless communication refers to communicating via wireless devices that acquire the energy needed for their operation from nature. Such devices can cooperate not only at the signal level, but also by sharing their harvested energy in order to improve network performance. While recent work addressed throughput optimizing policies for such channels, information theoretic performance limits are not yet established. In this work, we consider a Gaussian energy harvesting channel with two energy harvesting nodes and compute its capacity in the presence of the possibility of energy transfer between the two.

TP4b-2 3:55 PM

Sum-rate Analysis for Systems with Wireless Energy Transfer

Rania Morsi, Derrick Wing Kwan Ng, Robert Schober, Friedrich-Alexander University of Erlangen-Nuremberg, Germany

Energy harvesting based mobile communication system design enables self-sustainability of energy constrained wireless devices. This paper studies the performance of wirelessly powered communication systems. We analyze the sum-rate of a protocol where single antenna receivers harvest energy from a multiple antenna transmitter in the downlink by wireless energy transfer to support their wireless information transmission in the uplink. We first derive the optimal downlink energy transmission strategy maximizing the total harvested energy at the receivers subject to a total transmit power constraint. Then, an analytical expression for the uplink sum-rate is derived to provide valuable insights for system design. Simulation results verify our analytical results and illustrate the trade-off between sum-rate and energy transfer.

TP4b-3 4:20 PM

Optimal Energy Routing in Networks with Energy Cooperation

B. Gurakan, O. Ozel, Sennur Ulukus, University of Maryland, United States

We consider a multi-user multi-hop wireless communication network where all nodes can harvest energy from nature and all nodes can transfer energy from one to another. This is a model of an energy self-sufficient, energy self-sustaining autonomous wireless network. In this network, we determine the jointly optimum data packet scheduling and wireless energy transfer policies in order to maximize the end-to-end throughput. These policies determine the joint optimum flow of information and energy in the network.

TP4b-4 4:45 PM

Renewables Powered Mobile Cloud Offloading

Kaibin Huang, University of Hong Kong, Hong Kong SAR of China

The paper considers cloud radio access networks with renewables powered mobiles. Offloading computation-intensive tasks from mobiles to the cloud can improve their computation capability and reduce energy consumption. Nevertheless, offloading also consumes energy for transmission. Given this tradeoff, it is critical to optimize the offloading process based on the states of the channel, energy and computation tasks so as to cope with energy intermittence and maximize the battery life. In this paper, mobile offloading is formulated as a Markov decision process based on multiple Markov chains modeling the random energy arrivals, dynamic computation tasks and wireless channel. The structure of the optimal policy is analyzed using stochastic optimization theory. Furthermore, the fundamental gains of mobile offloading in terms of computation capability and battery life are quantified.

Session: TPa5 – Speech Enhancement

Chair: ***Dalei Wu,*** *Nanjing University of Posts and Telecommunications*

TP5a-1 1:30 PM

Noise Power Spectral Density Matrix Estimation Based on Improved IMCRA

Qipeng Gong, Benoit Champagne, Peter Kabal, McGill University, Canada

In this paper, we present a new method for noise power spectral density (PSD) matrix estimation based on IMCRA which consists of two parts. For the auto-PSD (diagonal) estimation, we propose a modification to IMCRA where a special level detector is employed to improve the tracking of non-stationary noise backgrounds. For the cross-PSD (offdiagonal) estimation, we propose to calculate a smoothed cross-periodogram by using estimated noise components derived as residuals after the application of a speech enhancement algorithm on the individual microphone signals. Simulation results show the effectiveness of our proposed approach in estimating the noise PSD matrix and its robustness against reverberation when used in combination with an MVDR-based speech enhancement system.

TP5a-2 1:55 PM

BI-CosampSE: Block Identification based Compressive Sampling Matching Pursuit for Speech Enhancement

Dalei Wu, Nanjing University of Posts and Telecommunications, China; Wei-Ping Zhu, M.N.S. Swamy, Concordia university, Canada

In this paper, we propose a novel method to tackle this problem by using a block based identification strategy (BIS) to seek the most prominent components in the observed data to update the sparse estimate of CoSaMP. The proposed method has been found to be very effective to reduce musical noise in speech enhancement, in combination with some time-frequency smoothing techniques.

TP5a-3 2:20 PM

Pitch Estimation for Non-Stationary Speech

Mads Græsbøll Christensen, Jesper Rindom Jensen, Aalborg University, Denmark

Recently, parametric methods based on the harmonic model have proven to be capable of overcoming the problems of correlation-based methods. However, the argument against parametric methods is that the model is wrong, particularly for non-stationary signals like speech. To address this, we propose a new chirp model for pitch estimation in speech. This model takes the non-stationary nature of the pitch explicitly into account, and we derive an estimator for determining the parameters of the model. In experiments, we investigate the properties and capabilities of the model and the estimator and investigate whether it is needed for pitch estimation.

TP5a-4 2:45 PM

Estimating the Noncircularity of Latent Components within Complex-Valued Subband Mixtures with Applications to Speech Processing

Greg Okopal, Scott Wisdom, Les Atlas, University of Washington, United States

This paper describes an approach that estimates the circularity coefficients of multiple underlying components within complex subbands of an additive mixture of voiced speech and noise via the strong uncorrelating transform (SUT). For the SUT to be effective, the latent source signals must have unique nonzero circularity coefficients; this requirement is satisfied by using narrow filters to impose a degree of noncircularity upon what would typically be circular noise. The circularity coefficient estimates are then used for voice activity detection, pitch tracking, and enhancement.

Session: TPb5 – Full Duplex MIMO Radio

Chair: ***Yingbo Hua,*** *University of California, Riverside*

TP5b-1 3:30 PM

Non-Linear Distortion Cancellation in Full Digital Domain for Full Duplex Radios

Yang-Seok Choi, Feng Xue, Roya Doostnejad, Shilpa Talwar, Intel Corporation, United States

Analogue domain cancellation of echoes for full duplex has been suggested. However, still considerable power of residual echoes appears at receive chain. The residual echoes include not only linear term of transmitted signal but also non-linear terms as well due to non-linear behavior of power amplifier (PA). In this presentation, we propose methods of cancelling the residual echoes using adaptive filter in digital domain. PA can be modeled by linear combination of multiple kernels. Each kernel goes to an adaptive filter and each adaptive filter estimates the corresponding kernel of received residual echoes and cancels the residual echoes.

TP5b-2 3:55 PM

Blind Digital Tuning for Interference Cancellation in Full-Duplex Radio

Yingbo Hua, University of California, Riverside, United States

Interference cancellation is critical for full-duplex radio where self-interferences must be removed. Although the source of an interference in such context can be tapped, the hardware impairments such as phase noises and IQ imbalances severely limit the performance of cancellation by conventional adaptive methods. Also the high cost of obtaining accurate measurement of the RF signal before each attenuator in an adaptive transversal RF filter makes the conventional methods infeasible. In this paper, we present a recent progress in developing a blind digital tuning strategy. This strategy avoids the use of expensive hardware and is robust against hardware impairments.

TP5b-3 4:20 PM

On In-Band Full-Duplex MIMO Radios with Transmit and Receive Antenna Reuse

Daniel Bliss, Yu Rong, Arizona State University, United States

In-band (cochannel) full-duplex multiple-input multiple-output (MIMO) radios with antenna reuse employ an array of antennas for which each antenna transmits and receives simultaneously. One of the most significant challenges is the mitigation of the radio's self-interference. We consider the performance constraints of these MIMO full-duplex nodes. We consider three self-interference mitigation approaches including there interactions under the assumption of nonideal hardware. The self-interference mitigation approaches include circulators, radio frequency (RF) active suppression, and temporal baseband self-interference mitigation. We assume simultaneous communications and channel probing. We explore performance as a function of parameterized hardware nonidealities.

TP5b-4 4:45 PM

MIMO Broadcast Channel with Continuous Feedback using Full-duplex Radios

Xu Du, Rice University, United States; Christopher Dick, Xilinx Incorporated, United States; Ashutosh Sabharwal, Rice University, United States

In this paper, we study the use of full-duplex radios for continuous feedback of channel state information in MIMO broadcast channels. The simultaneous transmission of feedback on the same frequency band as downlink transmissions causes inter-node interference at the receiver. We quantify the impact of this inter-node interference and associated tradeoffs in the design of the feedback channel.

Track E – Array Signal Processing

Session: TPa6 – Passive and Multistatic Radars

Chair: ***Muralidhar Rangaswamy,*** *Air Force Research Labs*

TP6a-1 1:30 PM

Passive Multistatic Radar Based on Long-term Evolution Signals

Sandeep Gogineni, Wright State Research Institute, United States; Muralidhar Rangaswamy, Wright Patterson Air Force Base - AFRL, United States; Arye Nehorai, Washington University in St. Louis, United States

Passive multistatic radar has drawn much attention in recent years owing to the several advantages of operating in a distributed configuration that have already been demonstrated for active radar. In a passive setup, the transmitted signal can be selected from among several illuminators occupying the electromagnetic spectrum. In this paper, we compute the non-coherent and coherent ambiguity function expressions using 4G long term evolution signals as the illuminators of opportunity.

TP6a-2 1:55 PM

A Correlation-Based Signal Detection Algorithm in Passive Radar with DVB-T2 Emitter

Guolong Cui, Hongbin Li, Stevens Institute of Technology, United States; Braham Himed, Air Force Research Laboratory, United States

This paper considers target detection in passive radar that employs a digital video broadcasting-terrestrial version 2 (DVB-T2) emitter as an illuminator of opportunity. The target detection is equivalent to identifying the presence/absence of the DVB-T2 signal in the returns. A correlation-based detection strategy is proposed by exploiting a unique C-A-B structure of the P1 symbol that is ubiquitous in all DVB-T2 transmissions. The P1 symbol, originally introduced for a DVB-T2 receiver to obtain synchronization, is exploited here for target detection. The performance of the proposed detector is evaluated by Monte Carlo simulations. Our results show that the proposed detector can reliably detect the target without full knowledge of the DVB-T2 signal waveform (except for the C-A-B structure).

TP6a-3 2:20 PM

Improving Multistatic MIMO Radar Performance in Data-Limited Scenarios

Tariq Qureshi, Muralidhar Rangaswamy, Air Force Research Laboratory, United States; Kristine Bell, Metron Inc., United States

A MIMO Multistatic radar system consists of multiple bistatic MIMO pairs working in potentially different configurations. If a bistatic pair in a Multistatic MIMO radar system employs multiple transmit and receive elements, this increases the dimensionality of the data received over a Coherent Processing Interval (CPI), which in turn increases the training data needed to reliably estimate the covariance matrix. This, coupled with the non-stationarity in the received data resulting from the bistatic geometry further degrades the quality of the covariance matrix estimate used in the adaptive detector. In [1], Kristine Bell et al. presented a physics based MIMO clutter model, and showed that lack of training data support renders the MIMO radar unfeasible in that the individual bistatic pairs can outperform the overall MIMO system. In this paper, we investigate techniques to improve the performance of the multistatic MIMO radar in data limited scenarios. More specifically, we seek a parametric approximation to the clutter as an AR process, resulting in a reduction in the amount of data that is needed to reliably estimate the AR parameters. We compare the performance of the parametric approximation to the case where the covariance matrix is estimated as a sample average using the same amout of training data.

TP6a-4 2:45 PM

Market based Sensor Mobility Management for Target Localization

Nianxia Cao, Swastik Brahma, Pramod Varshney, Syracuse University, United States

We propose a framework for the mobile sensor scheduling problem in target localization by designing an equilibrium based two-sided market model where the fusion center (FC) is modeled as the consumer and the mobile sensors are modeled as the producers. The FC motivates the sensors to optimally relocate themselves that maximizes its information gain for estimation. On the other hand, the sensors calculate their own best moving distances that maximize their profits. Price adjustment rules are designed to compute the equilibrium prices and moving distances, so that a stable solution is reached. Simulation experiments show the effectiveness of our model.

Session: TPb6 – Many-Core Platforms

Chair: ***Mats Brorsson,*** *KTH*

TP6b-1 3:30 PM

Towards Modeling and Analyzing Performance of LTE Base Station Software

Konstantin Popov, SICS, Sweden; Mats Brorsson, KTH Royal Institute of Technology, Sweden

We present a software model of LTE uplink data processing in 3GPP Radio Base Stations (eNodeB). The model is developed in ArchiDeS, a a lean yet expressive framework for developing message-passing component-based applications. ArchiDeS enables application- and platform-specific scheduling of parallel execution on multicore architectures. ArchiDeS' implementation as a C++ library has low and predictable overhead. The LTE model captures all available concurrency at the component level, which enables parallel execution on large-scale multicore systems such as Tilera. Still, executing the model on tens of cores requires careful scheduling and synchronization. We present and analyze our experiences with the model and ArhiDeS.

TP6b-2 3:55 PM

REPLICA T7-16-128 - A 2048-threaded 16-core 7-FU Chained VLIW Chip Multiprocessor

Martti Forsell, Jussi Roivainen, VTT, Finland

Processor-based solutions are getting increasingly popular over dedicated logic/accelerators among embedded system designers due to their flexibility. The drawbacks - weaker performance and higher power consumption - are usually compensated with application-specific multicore technologies. Unfortunately, these make programming difficult and result to less flexible designs. REPLICA is VTT's effort to solve the performance and programmability problems of current multicore processors without tampering flexibility. In this paper we introduce T7-16-128 - a 2048-threaded 16-core prototype of the REPLICA chip multiprocessor. The main principles of the architecture and structure of the prototype are explained. Preliminary comparison to current alternatives is given.

TP6b-3 4:20 PM

Improving Image Quality by SSIM Based Increase of Run-Length Zeros in GPGPU JPEG Encoding

Stefan Petersson, Håkan Grahn, Blekinge Institute of Technology, Sweden

This paper proposes an algorithm to improve the experienced quality in JPEG encoded images. The algorithm improves the quality in detailed areas while reducing the quality in less detailed areas of the image, thereby increasing the overall experienced quality without increasing the image data size. The algorithm is based on the SSIM metric and an efficient GPU implementation is presented.

TP6b-4 4:45 PM

Kickstarting High-Performing Energy-Efficient Manycore Architectures with Epiphany

Tomas Nordström, Zain ul-Abdin, Halmstad University, Sweden; Andreas Olofsson, Adapteva, United States

In this paper we introduce Epiphany as a high-performing energy-efficient manycore architecture suitable for high-end embedded systems. The outstanding performance per Watt (50 GFlops/W) makes this architecture a very strong candidate for all applications that do significant signal processing in embedded and mobile environments. We have exemplified the use of Epiphany in two such applications, radar applications and video processing. We have furthermore looked at various development environments and languages for this architecture. Finally we will discuss what additional architectural features can be expected in future generations of Epiphany.

Track G – Architecture and Implementation

Session: TPa7 – Design Methodologies for Signal Processing

Chair: ***Chris Lee,*** *NCKU*

TP7a-1 1:30 PM

Finding Fast Action Selectors for Dataflow Actors

Gustav Cedersjö, Jörn W. Janneck, Jonas Skeppstedt, Lund University, Sweden

Recent shift towards more parallel computing platforms and the popularization of stream applications such as signal processing, video encoding an cryptography has renewed the interest in dataflow programming. This paper builds on previous work on efficient implementations the basic elements of a dataflow program, the actors, and investigates heuristics for making the process of selecting what to do in an actor faster.

TP7a-2 1:55 PM

Automatic Generation of Application Specific FPGA Multicore Accelerators

Pascal Schleuniger, Andreas Hindborg, Nicklas Bo Jensen, Maxwell Walter, Laust Brock-Nannestad, Lars Bonnichsen, Christian W. Probst, Sven Karlsson, Technical University of Denmark, Denmark

High performance computing systems increasingly make use of hardware accelerators to improve performance and power properties. For large high-performance FPGAs to be successfully integrated in such computing systems, methods to raise the abstraction level of FPGAs programming are required. In this paper we propose a tool flow, which automatically generates highly optimized hardware multicore systems based on parameters. Profiling feedback is used to adjust these parameters to improve performance and lower the power consumption. For image and video processing applications, we show that our tools are able to optimize the hardware to deliver competitive performance at a low power budget.

TP7a-3 2:20 PM

Dataflow Toolset for Soft-Core Processors on FPGA for Image Processing Applications

Burak Bardak, Fahad Manzoor Siddiqui, Roger Woods, Queen's University Belfast, United Kingdom

This paper propose a design tool chain that uses dataflow language CAL[2] as a starting point and targets to custom design soft-core processor on FPGA. The main purpose for the design tool is exploiting the task and data parallelism in order to achieve the same parallelism as HDL implementation without dealing with the required design, verification and debugging steps of HDL design, which increases the time to market, and design effort.

TP7a-4 2:45 PM

An Enhanced and Embedded GNU Radio Flow

Ryan Marlow, Peter Athanas, Virginia Polytechnic Institute and State University, United States

This paper presents a Zynq capable version of GNU Radio -- an open-source rapid radio deployment tool -- with an enhanced flow that utilizes the processing capability of FPGAs. This work features TFlow -- an FPGA back-end compilation accelerator for instant FPGA assembly. The Xilinx Zynq FPGA architecture integrates the FPGA fabric and CPU onto a single chip, which eliminates the need for a controlling host computer; thus, providing a single, portable, low-power, embedded platform. By exploiting the computational advantages of FPGAs in the GNU Radio flow, a larger class of software defined radios can be implemented.

Track A – Communications Systems

Session: TPb7 – Optical Wireless Communications

Chair: ***Zhengyuan (Daniel) Xu,*** *University of Science and Technology of China*

TP7b-1 3:30 PM

Multiuser MISO Indoor Visible Light Communications

Jie Lian, Mohammad Noshad, Maite Brandt-Pearce, University of Virginia, United States

Visible light communications using LED fixtures simultaneously for indoor illumination and for transmission offer the promise of high throughput data connectivity in an energy and cost efficient manner. In this paper we explore algorithms for supporting many users concurrently by optimizing the use of individual LEDs in each luminary. The directivity and nonlinearity of each LED is considered when assigning multiple LEDs to a user, forming a multiple input single output (MISO) system. Exploiting the spatial separation of detectors, MISO techniques using CDMA and MMSE detection can offer high performance to many simultaneous users while preserving the properties of the lighting system, such as spatially and temporally continuous dimmable illumination.

TP7b-2 3:55 PM

Optical Spatial Modulation OFDM using Micro LEDs

Muhammad Ijaz, Dobroslav Tsonev, Abdelhamid Younis, University of Edinburgh, United Kingdom; Jonathan J. D. McKendry, Erdan Gu, Martin Dawson, University of Strathclyde, United Kingdom; Harald Haas, University of Edinburgh, United Kingdom

This paper investigates the performance of optical spatial modulation (OSM) with orthogonal frequency division multiplexing (OFDM) in a micro multiple-input multiple-output (μMIMO) based visible light communication (VLC) system. The micro light emitting diode (μLED) based cluster devices are considered in the current investigations. The simulation results show that a maximum achievable data rate using OSM-OFDM is 4.6 Gb/s using adaptive bit loading for 2×2 μMIMO. The results also indicate that due to the highly correlated channels, the system performance is largely dependent on the spatial separation and the light emission profile of the μLEDs in the clusters.

TP7b-3 4:20 PM

Adaptation of OFDM under Visible Light Communications and Illumination Constraints

Thomas Little, Hany Elgala, Boston University, United States

OFDM is increasingly studied and adopted as a modulation technique for RF and OW communication systems. In this paper we investigate challenges to the adoption of OFDM for use in lighting systems that support both intensity control and data communication. In particular, we survey the requirements for energy efficiency, intensity control (dimming), and LED driver integration in lighting systems. These requirements are mapped to contemporary and novel OFDM adaptations to show how both the lighting and communications needs can be met in dual-use scenarios while preserving both missions with reasonable performance.

TP7b-4 4:45 PM

Hybrid Dimmable Visible Light -with Infra-Red Optical Wireless Communications

Andrew Burton, Z Ghassemlooy, Edward Bently, Hoa LeMinh, Northumbria University, United Kingdom; S K Laiw, National Taiwan University of Science and Technology, Taiwan; Chung Ghiu Lee, Chosun University, Republic of Korea

This paper presents a new dimming technique for LEDs using a transparent pulse width modulation (PWM) scheme. A combination of white visible light and infrared (IR) LEDs are used to ensure data link availability at all times. When the visible LEDs are off the IR LEDs will be on and and vice versa. This hybrid lighting and data communication scheme ensure data communication even when visible light switched off. Since PWM signal is made transparent to the receiving electronics we drastically reduce the inter modulation interference (IMI) between the PWM and the data channel, and the need for synchronization at the transmitter between the two signals. Results show a bit error rate of $\leq$ 1e-6 for all data within the system bandwidth for all dimming levels.

Track A – Communications Systems

Session: TPa8 – Cognitive Radio II 1:30 PM–3:10 PM

Chair: ***Priyadip Ray,*** *IIT Kharagpur*

TP8a1-1

Characterization of Outage Performance for Cognitive Relay Networks with Mixed Fading

Efthymios Stathakis, Lars K. Rasmussen, Mikael Skoglund, Royal Institute of Technology (KTH), Sweden

We consider a dual-hop underlay cognitive radio network with a single transceiver pair, which utilizes an amplify-and-forward relay to establish end-to-end communication. The secondary nodes, i.e., the transmitter and the relay, obey transmit power constraints which guarantee that the instantaneous peak interference at the primary receiver will not exceed a certain threshold. Each of the secondary communication links contains a line-of-sight component whereas the external links, to the primary receiver, are subject to Rayleigh fading. For this system model, we analyze the outage probability and demonstrate the accuracy of the obtained mathematical expressions via numerical simulations.

TP8a1-2

Restless Multi-Armed Bandits under Time-Varying Activation Constraints

Kobi Cohen, Qing Zhao, Anna Scaglione, University of California, Davis, United States

We consider a class of restless multi-armed bandit (RMAB) problems, in which a player chooses K(t) out of N arms to play at each given time t. Each arm evolves according to a two-state Markov chain, independent of the player's action. While the problem is in general PSPACE-hard, we focus on the optimality of the myopic policy under a time-varying activation constraint K(t). The problem under study finds applications in various communication networks and also applies to the compressive spectrum sensing problem in cognitive radio networks.

TP8a1-3

On the Optimal Relay Design for Multi-Antenna Cognitive Two-Way AF Relay Networks

Maksym Girnyk, KTH Royal Institute of Technology, Sweden; Mikko Vehkaperä, Sergiy Vorobyov, Aalto University, Finland

Cognitive two-way relaying is an efficient method for tackling the problem of spectrum scarcity by serving new (secondary) users, while keeping the existing (primary) users satisfied with their service. Moreover, additional gains can be attained from employment of the two-way relaying with multipleantenna relays within the secondary network. In this paper, we consider an underlay two-way cognitive network and propose an efficient algorithm for computation of a (nearly) optimal relay precoder matrix subject to the interference constraint towards the primary network. The efficiency of the proposed solution will be highlighted by means of numerical simulations in the full version of the paper

TP8a1-4

Network Aware Spectrum Efficiency Metric for Heterogeneous and Dynamic Radio Environments

Aditya Padaki, Ravi Tandon, Jeffrey Reed, Virginia Polytechnic Institute and State University, United States

In this paper, we formalize a new definition for spectrum efficiency, with the specific goal of addressing the diverse needs and requirements of various technologies and users. Existing metrics for spectrum efficiency are insufficient for future systems which employ dynamic allocation schemes. We introduce a parameterized definition for spectrum efficiency dependent on the network dynamics, radio environment and diverse requirements of technologies. This metric accounts for the frequency use and reuse, interference footprint of a user, and has a parameter to specify priority/importance for users/bits (e.g. public safety). We then evaluate the spectrum efficiency regions for three different network architectures.

TP8a1-5

A Unified Framework for Robust Cooperative Spectrum Sensing

Qi Cheng, Eric Chan-Tin, Oklahoma State University, United States

In cognitive radio, spectrum sensing performance may be degraded by various sensor faults and/or security threats, including device malfunctions and Byzantine attacks. We propose a robust spectrum sensing framework including two steps of faulty node detection followed by faulty node elimination or correction before decision fusion. The first step explores the decision statistics over time to identify faulty nodes. The second step relies on the mutual behavior check among the remaining nodes. Clustering is applied to decision sequences to distinguish faulty from normal nodes, and faulty model estimation, which is then used for data correction.

TP8a1-6

Receiver Configuration and Testbed Development for Underwater Cognitive Channelization

George Sklivanitis, Emrecan Demirors, Stella N. Batalama, Tommaso Melodia, Dimitris A. Pados, State University of New York at Buffalo, United States

We propose a receiver configuration and we develop a software-defined-radio testbed for real-time cognitive underwater multiple-access communications. In particular, the proposed receiver is fully reconfigurable and executes (i) all-spectrum cognitive channelization and (ii) combined synchronization, channel estimation, and demodulation. Real-time experimental results with in-house built modems demonstrate our theoretical developments and show that cognitive channelization is a powerful proposition for underwater communications and leads to significant improvement of the spectrum utilization. Even in the absence of interference, due to the noise characteristics of the acoustic channel, cognitive channelization offers significant performance improvements in terms of receiver pre-detection signal-to-interference-plus-noise-ratio and bit-error-rate.

TP8a1-7
Estimation of Subspace Occupancy
Kaitlyn Beaudet, Douglas Cochran, Arizona State University, United States

The ability to identify unoccupied resources in the radio spectrum is a key capability for opportunistic user in a cognitive radio environment. This paper draws upon and extends geometrically based ideas in statistical signal processing to develop estimators for the rank and the occupied subspace in a multi-user environment from multiple temporal samples of the signal received at a single antenna. These estimators enable identification of resources (i.e., the orthogonal complement of the occupied subspace) that may be exploitable by an opportunistic user.

TP8a1-8
Performance Analysis: DF Cognitive Network with Transceiver Imperfections
Dang Khoa Nguyen, Kyushu Institute of Technology, Japan; Tu Thanh Lam, Post and Telecommunications Institute of Technology, Viet Nam; Hiroshi Ochi, Kyushu Institute of Technology, Japan

We comprehensively analyze the outage performance of dual-hop decode-and-forward (DF) cognitive network subject to independent non-identical distributed Rayleigh fading with the presence of hardware impairment level in the model of transceiver nodes of cognitive network.Closed-form expressions of exact and asymptotic of outage probability of the DF cognitive network are derived. A numerical simulation study is showed to corroborate our analysis results. Thereby, we found that hardware impairment level sharply impact outage performance of DF cognitive network. The influence of this factor is small at the low transmit power but the bad effect is higher when transmission power is increased.

Track D – Signal Processing and Adaptive Systems
Session: TPa8 – Signal Processing Methods 1:30 PM–3:10 PM
Chair: ***Seung Jun Kim,*** *University of Maryland, Baltimore County*

TP8a2-1
Blind Equalization Based On Blind Separation with Toeplitz Constraint
Zhengwei Wu, Saleem Kassam, University of Pennsylvania, United States

Blind equalization (BE) has been modeled as a blind source separation (BSS) problem and achieved using BSS algorithms. We show that the Toeplitz structure of the mixing matrix in the BSS model for BE can be exploited for faster convergence and better performance. A length constraint on the equalizer impulse response provides further improvement. We use the equivariant adaptive separation via independence (EASI) algorithm to illustrate the ideas, although the approach is generally applicable. Simulation results and comparisons are given. The method can be extended for multiple channels and fractional sampling.

TP8a2-2
Piecewise-Constant Recovery via Spike-and-Slab Approximate Message-Passing using a Scalarwise Denoiser
Jaewook Kang, Heung-No Lee, Kiseon Kim, Gwangju Institute of Science and Technology (GIST), Republic of Korea

This paper proposes a novel AMP algorithm for recovery of piecewise-constant signals under the compressed sensing framework, called ssAMP. The ssAMP solver includes a low-complex scalarwise denoiser; therefore, its overall complexity is significantly reduced in a high-dimensional setting compared to an existing AMP for the piecewise-constant recovery, TV-AMP. In addition, the ssAMP iteration consists of fully scalarwise operations. Hence, the ssAMP is further accelerated via parallelization, whereas TV-AMP cannot be parallelized. We provide a summary of the algorithm construction, discussing the superiority of ssAMP compared to the conventional total variation approaches through experimental simulations.

TP8a2-3
Resource Allocation Optimization for Distributed Vector Estimation with Digital Transmission
Alireza Sani, Azadeh Vosoughi, University of Central Florida, United States

We consider the problem of distributed estimation of an unknown random vector with a known covariance matrix in a wireless sensor network. Sensors transmit their binary modulated quantized observations to a fusion center(FC), over orthogonal MAC channels subject to fading and additive noise. Assuming the FC employs the linear minimum mean-square error (MMSE)

estimator, we obtain an upper bound on MSE distortion. We investigate optimal resource allocation strategies that minimize the MSE bound, subject to total bandwidth (measured in quantization bits) and total transmit power constraints. Our simulation show that the proposed scheme outperforms uniform bit and power allocation scheme.

TP8a2-4
Exploiting the Cramér-Rao Bound for Optimised Sampling and Quantisation of FRI Signals

Andre Angierski, Volker Kuehn, University of Rostock, Germany

This contribution considers the sampling process for Finite Rate of Innovation signals including quantisation errors and additive white Gaussian noise. For some applications the total amount of bits available for the sampling process is constrained, e.g. due to memory limitations. Thus, the sharing of these bits between sampling rate and the quantisation accuracy has to be optimised. In particular, the Cramér-Rao bound is determined and the bit allocation is optimised w.r.t. the CRB. Finally, the analytical results are compared with simulation results obtained by spectral estimation methods.

TP8a2-5
Adaptive Waveform for Integrated Detection and Identification of Moving Extended Target

Jo-Yen Nieh, Ric Romero, Naval Postgraduate School, United States

We propose an improvement to the maximum a posteriori probability weighted eigenwaveform (MAP-PWE) adaptive waveform design used in target recognition with a cognitive radar platform for which we call match-filtered PWE (MF-PWE). Our interest however is to include moving targets in the identification problem. Combining range-Doppler map (RDM) technique with the the PWE-based adaptive waveform techniques, we propose an integrated detection and identification scheme for moving extended targets. Target detection performance comparison between wideband, MAP-PWE, and MF-PWE techniques are shown. It is noted the MF-PWE performs better than the wideband and MAP-PWE.

TP8a2-6
Channel Gain Cartography Via Low Rank and Sparsity

Donghoon Lee, Seung-Jun Kim, University of Minnesota, United States

Channel gain cartography aims at inferring shadow fading between arbitrary points in space based on measurements (samples) of channel gains taken from finite pairs of transceivers. Channel gain maps are useful for various sensing and resource allocation tasks essential for the operation of cognitive radio networks. In this work, the channel gain samples are modeled as compressive tomographic measurements of an underlying spatial loss field (SLF), which is postulated to have a low-rank structure corrupted by sparse errors. Efficient algorithms to reconstruct the SLF are developed, from which arbitrary channel gains can be interpolated.

TP8a2-7
Bayesian Cramér-Rao Bound for Distributed Estimation of Correlated Data with Non-linear Observation Model

Mojtaba Shirazi, Azadeh Vosoughi, University of Central Florida, United States

In this paper we study the problem of distributed estimation of a random vector in wireless sensor networks (WSNs) with non-linear observation models. Sensors transmit their modulated quantized observations over orthogonal erroneous wireless channels (subject to fading and noise) to a fusion center, which estimates the unknown vector. We derive the Bayesian Cramer-Rao Bound (CRB) matrix and study the behavior of its trace (through analysis and simulations), with respect to the observation and communication channel signal-to noise ratios (SNRs). The derived CRB serves as a benchmark for performance comparison of different Bayesian estimators, including linear MMSE estimator.

TP8a2-8
Multirate Processing Using Nested Sampling

Peter Vouras, Naval Research Laboratory, United States

This paper describes the multirate processing of random signals sampled on nested intervals. Nested sampling intervals consist of nonuniformly spaced samples formed by concatenating two or more smaller intervals each with uniform sampling. By filtering a vectorized version of the power spectral density matrix of the signal, the input-output behavior of conventional filter banks can be replicated. Simulated examples are presented which describe the application of the proposed technique to adaptive doppler processing in radars.

Session: TPa8 – Image Processing II 1:30 PM–3:10 PM

Chair: ***Ashkan Ashrafi,*** *San Diego State University*

TP8a3-1

Smoothed Rank Approximation Algorithms for Matrix Completion

Mohammed Al-Qizwini, Hayder Radha, Michigan State University, United States

We consider using smooth rank approximation functions to solve the matrix completion problem. Our main contribution in this paper is deriving two robust algorithms using the Accelerated Proximal Gradient (APG) and the Alternating Direction Method of Multipliers (ADM). Further, we compare both algorithms against each other and against the iterative reweighted least squares (IRLS-1) algorithm using a variety of noisy images. The experiments show that using ADM achieves approximately 1.5 dB SNR improvement over IRLS-1, while it needs comparable execution time to IRLS-1. Meanwhile, using APG saves about 50% of IRLS-1's computation time with lower SNR than ADM.

TP8a3-2

Visibility Prediction of Flicker Distortions on Naturalistic Videos

Lark Kwon Choi, Lawrence Cormack, Alan Bovik, University of Texas at Austin, United States

We conducted human studies where we found that the visibility of flicker distortions on naturalistic videos is strongly reduced in the presence of large coherent object motions. Based on this finding, we propose a model of flicker visibility. The model predicts target-related activation levels of neurons corresponding to the displayed video using spatiotemporal backward masking, then applies flicker adaptation. Results show that predictions of flicker visibility using the model are highly consistent with human perception of flicker distortions on naturalistic videos. We believe that these results are important for understanding temporal perceptual distortions, and how to predict and ameliorate them.

TP8a3-3

Image Compression via Wavelets and Row Compression

Mary HudachekBuswell, Georgia Institute of Technology, United States; Michael Stewart, Saied Belkasim, Georgia State University, United States

This work exploits a stable row compression algorithm for decomposing a hierarchically or sequentially structured matrix to compress an n x n image represented by a wavelet transform. The multiresolution discrete wavelet transform is used to decompose an image. The row compression algorithm builds up a low rank approximation of the wavelet transform by applying orthogonal transformations and updating techniques. The cost is O(n^2) operations.

TP8a3-4

Low Complexity Dimensionality Reduction for Hyperspectral Images

Seda Senay, Hector Erives, New Mexico Institute of Mining and Technology, United States

Although optimal, due to its computational complexity and of its being data dependent Karhunen Loeve Transform (KLT) is not practical to be used for data compression in resource constrained hyperspectral sensing platform. Based on their relationship with the KLT, we propose using discrete prolate sheroidal sequences (DPSSs) in hyperspectral imaging such that DPSSs decomposition can be applied as a suitable transform for compression. The performance of the proposed method is promising and open to improvements for further accuracy and dimensionality reduction such as for detection of certain targets for which the spectral signature is known.

TP8a3-5

Improving Image Clustering using Sparse Text and the Wisdom of the Crowds

Anna Ma, Claremont Graduate University, United States; Arjuna Flenner, Naval Air Warfare Center, United States; Deanna Needell, Claremont McKenna College, United States; Allon Percus, Claremont Graduate University, United States

We propose a method to improve image clustering using sparse text and the wisdom of the crowds. In particular, we present a method to fuse two different kinds of document features, image and text features, and use a common dictionary or ``wisdom of the crowds'' as the connection between the two different kinds of documents. With the proposed fusion matrix, we use topic modeling via non-negative matrix factorization to cluster documents.

TP8a3-6
Color Image Watermarking Using Quaternion Wavelets
Lahouari Ghouti, King Fahd University of Petroleum and Minerals, Saudi Arabia

In this paper, we propose a new color image watermarking algorithm using quaternion wavelets and semi-random low density parity check (SRLDPC) codes. Qauternion wavelets enable efficient watermark embedding in the hypercomplex domain without incurring additional computational complexity. The watermark detection is based on statistical maximum likelihood approaches. The efficiency and data hiding capacity of the proposed watermark embedding scheme are found to be greatly enhanced by the use of SR-LDPC codes.

TP8a3-7
Immersion Ultrasonic Array Imaging Using a New Array Spatial Signature in Different Imaging Algorithms
Nasim Moallemi, Shahram Shahbazpanahi, University of Ontario Institute of technology, Canada

In this paper, we investigate the performance of a new array spatial signature for imaging the material under immersion ultrasonic test. We have used this new array spatial signature in imaging algorithms including the conventional beamforming, MUSIC, and Capon algorithms. These three methods traditionally proposed for a homogeneous medium where the sound velocity is constant in the material under test. Note however that, in immersion ultrasonic test, the sound wave propagates with different speeds in water and in solid test sample. The new array spatial signature has been developed using distributed source modeling of the interface between water and solid.

TP8a3-8
A Proof on the Invariance of the Hirschman Uncertainty to the Rényi Entropy Parameter and an Observation on its Relevance in the Image Texture Classification Problem
Kirandeep Ghuman, Victor DeBrunner, Florida State University, United States

In [1] we developed a new uncertainty measure which incorporates Rényi entropy instead of Shannon entropy. This new uncertainty measure was conjectured to be invariant to the Rényi order alpha > 0 . We prove this invariance, and test whether this invariance is predictive in the problem of texture classification for digital images. In preliminary results, we find that it does, in that the recognition performance does not depend significantly on the Rényi parameter, as compared to the texture classification performance without using entropy. We hope that these results will be extended to other problems where Rényi entropy is used.

Track C – Networks

Session: TPa8 – Sensor and Wireless Networks 1:30 PM–3:10 PM

Chair: ***Usman Khan,*** *Tufts University*

TP8a4-1
Design of Orthogonal Golomb Rulers with Applications in Wireless Localization.
Omotayo Oshiga, Giuseppe Abreu, Jacobs University Bremen, Germany

Golomb rulers are useful in wide applications in engineering. Yet, the design of multiple mutually orthogonal GRs finds no solution in current literature. We present an algorithm to solve this problem. Our solution is based on modification of a classic algorithm, which allows the construction of GRs out of constrained sets of marks, such that orthogonal rulers can be obtained. A new algorithm is offered, which solves the intended problem and which indicates a gain when applied to generate optimal GRs. Wireless localization is used to illustrate the gains achievable when employing orthogonal GRs to perform multipoint ranging.

TP8a4-2
Secrecy Outage Analysis of Cognitive Wireless Sensor Networks
Satyanarayana Vuppala, Jacobs University Bremen, Germany; Weigang Liu, Tharmalingam Ratnarajah, University of Edinburgh, United Kingdom; Giuseppe Abreu, Jacobs University Bremen, Germany

We examine the secrecy outage of primary links in cognitive wireless sensor networks with interference from secondary users, offering original and highly accurate expressions for the aggregate interference with fading and shadowing. It is found that the presence of shadowing has a significant impact which can swiftly increase secrecy outage. The expressions derived can also be used to obtain other analytical results such as secrecy rate and secrecy transmission capacity.

TP8a4-3

On the Convergence Rate of Swap-Collide Algorithm for Simple Task Assignment

Sam Safavi, Usman A. Khan, Tufts University, United States

This paper provides a convergence rate analysis of the swap-collide algorithm for simple assignment problems. Swap-collide is a distributed algorithm that assigns a unique task to each agent assuming that the cost of each assignment is identical and has applications in resource-constrained multi-agent systems; prior work has shown that this assignment procedure converges in finite-time. In this paper, we provide an analytical framework to establish the convergence rate of swap-collide, and show that for a network of size N, the lower and upper bounds for the convergence rate are $O({N}^{3})$.

TP8a4-4

On the Impact of Low-Rank Interference on Distributed Multi-Agent Optimization

Chenguang Xi, Usman A. Khan, Tufts University, United States

We study the impact of low-rank interference on the problem of optimizing a sum of convex functions corresponding to multiple agents. We prove that the impact of interference can mathematically be regarded as additional constraints to original unconstrained optimization. The proposed analysis uses the notion of interference alignment where the agent transmissions are aligned in either the null space or range space of interference. We consider two cases:~(i) when the interference is uniquely determined by the transmitter; and,~(ii) when the interference is only determined by the receiver. Experiments on distributed source localization demonstrate good performance of our strategy.

TP8a4-5

Multipath-Aided Cooperative Network Localization Using Convex Optimization

Hassan Naseri, Mario Pereira da Costa, Visa Koivunen, Aalto University, Finland

Localization in the face of multipath propagation is a challenging task in sensor networks using radio, acoustic or underwater signals for distance measurement. Multipath-aided network localization exploits multipath propagation to improve the identifiability and performance of cooperative localization. In this paper the problem of multipath-aided network localization is formulated as an optimization problem and a semidefinite relaxation is proposed for it.

TP8a4-6

Mobile Sensor Mapping via Semi-Definite Programming

Giuseppe Destino, Davide Macagnano, University of Oulu, Finland

We consider the problem of mapping the locations of a mobile device into the Euclidean space utilizing its perception of the environment through sensors, e.g. WiFi. Based on the graph-based Simulatenous Localization and Mapping (SLAM) formulation, a semi-definite programming approach is derived in order to ensure convergence. To obtain a semi-definite program we exploit a convex likelihood model to constrain near mobile locations to similar environment perceptions as well as the Euclidean distance matrix properties for the resulting trajectory. Comparison with the state-of-the-art, i.e Gaussian Process and classic graph-SLAM methods will be provided in the final version of the paper.

TP8a4-7

Indoor Node Localization using Geometric Dilution of Precision in Ad-Hoc Sensor Networks

Sudhir Kumar, Rajesh M. Hegde, Indian Institute of Technology Kanpur, India

In this paper, a new method for sensor node localization using geometric dilution of precision (GDOP) is described. In contrast to the existing algorithms, the proposed algorithm is not constrained by fixed geometry of sensor node placement. Additionally, the GDOP can be used for effective localization under both line-of-sight and non-line-of-sight communication between sensor nodes in an ad-hoc sensor network. The robustness of the algorithm is due to the fair utilization of all measurements obtained under NLOS conditions. Location estimates are obtained using the method of GDOP which has hitherto been used for optimal placement of satellites. Algorithms using minimum and weighted-GDOP are discussed in the context of indoor sensor node localization. Extensive simulations and real field deployments are used to evaluate the performance of the proposed algorithm. The localization accuracy of the proposed algorithms is reasonably better when compared to similar methods in literature.

TP8a4-8

Efficient Consensus Synchronization via Implicit Acknowledgment

Andrew G. Klein, Western Washington University, United States; D. Richard Brown III, Worcester Polytechnic Institute, United States

A technique for achieving synchronization in wireless networks using only existing traffic is developed. Prior work has either ignored propagation delay, or has required bidirectional messages consisting of explicitly acknowledged unicast transmissions. We develop an approach using "implicit acknowledgment" that achieves precise consensus synchronization by exploiting the broadcast nature of the wireless medium. This significantly reduces the number of transmissions needed for synchronization throughout the network, and is applicable to networks with unacknowledged multicast and broadcast traffic. Results suggest the technique is effective for precise, low-overhead network synchronization, and numerical results are presented for two particular network configurations.

Track A – Communications Systems

Session: TPb8 – Topics in Communication Systems 3:30 PM–5:10 PM

Chair: ***Alexios Balatsoukas-Stimming,*** *EPFL*

TP8b1-1

Performance Analysis of a MMSE Turbo Equalizer with LDPC in a FTN Channel with Application to Digital Video Broadcast

Ghassan Maalouli, Brian A. Banister, Comtech EF Data, United States

The advent of digital wireless communications of the past two decades has created an unprecedented spectral demand. One of the most demanding applications is Digital Video Broadcast (DVB). DVB bandwidth requirements have motivated academic as well as practicing researchers to find more efficient schemes that can increase spectral efficiency. This led the DVB industry to adopt higher order modulations and efficient coding techniques, such as LDPC, which resulted in performance that approaches the Shannon limit to within a few fractions of a decibel. More recently, the DVB community has focused its attention on FTN signaling as a method that may achieve higher capacity. This is attained by transmitting signals at a rate that is faster than the Nyquist rate into a band-limited channel. In his seminal work, Harry Nyquist established the ISI-free limit at which a signal can be transmitted through a channel. Emitting the signal at a faster rate incurs inter-symbol interference (ISI). If ISI is un-mitigated, it will degrade system performance beyond the capacity improvement that is attained by FTN signaling, rendering the approach useless. However, if ISI is mitigated, it is possible under certain scenarios to completely eliminate ISI or at least reduce it such that there is a net capacity gain through the channel. Several researchers have studied the problem of eliminating ISI in a multipath channel using turbo-equalization techniques. It was well established that the optimal equalizer comprises a trellis that combines the channel's memory as well as the decoder's. However such architecture is suitable only for short channels and lower order modulations. Otherwise, the size of the trellis will be computationally prohibitive for real-time applications even with modern day technology. Therefore attention shifted towards architectures that are practically amicable. In this work, we investigate the performance of computationally efficient, MMSE-based turbo-equalizers with a LDPC decoder and study their ability to eliminate ISI in a FTN channel. We analyze the performance of MMSE with and without feedback in low and high SNR regimes. We measure the SNR degradation that the system incurs after ISI mitigation. We quantify the net gain in capacity that the system can potentially attain. We demonstrate that the MMSE suffers high degradation at low SNR but converges to a few tenth of a dB from the zero ISI condition at higher SNR. On the contrary, a Soft-feedback-equalizer (SFE) suffers very little degradation at low SNR but converges to a BER rate that is higher than the MMSE for the same SNR. Selecting the proper structure is therefore dependent on the desired operating point of the receiver.

TP8b1-2

Characteristics of Optical Scattering and Turbulence Communication Channels

Weihao Liu, Zhengyuan Xu, University of Science and Technology of China, China

The optical scattering and turbulence channels are modeled by the semi-analytic and semi-numerical (SASN) method, in which the ray tracing model based on Monte-Carlo method is used to track the multiple scattering ray and analytic method is to get the irradiance distribution of each individual ray. Characteristics of the scattering and turbulence channels are uncovered as follows: 1) mean path loss increase with turbulence strength; 2) scintillation index is much reduced because of the smooth effect of multiple scattering; 3) the multiple scattering and turbulence channel can be well represented by the lognormal distribution function of small variance.

TP8b1-3

Comparison of SNR and Peak-SNR (PSNR) Performance Measures and Signals for Peak-limited Two-Dimensional (2D) Pixelated Optical Wireless Communication

Eyal Katz, Yeheskel Bar-Ness, New Jersey Institute of Technology, United States

Two-dimensional(2D) pixelated-Optical-Wireless-Communication-Systems (OWCS), with Intensity-Modulation, Direct-Detection (IM/DD), commonly use computer-display (transmit-side), and camera (receive-side). One-dimensional(1D) IM/DD OWCS and channels, are average-power-limited, due to eye-safety rules. 2D pixelated-channels are peak-limited. However, in-the-literature, both 1D and 2D systems-evaluations use Average-power Signal-to-Noise Ratio (Average-power SNR). We first show, for different 2D-signals, passing through fixed-2D-channels, that same-Average-power-SNR results, coincide with different input-noise levels, thus may-considered as biased. This bias found-to-be related to the signal's Peak-to-Average Power-Ratio (PAPR). We approximate the performance using Peak-power Signal-to-Noise-Ratio (PSNR). Optimizing signal for maximum variance, given a peak-limited-channel, under PSNR; Concluding with such signal-example showing superior-performance when-compared to known-method.

TP8b1-4

I.I.D. Stochastic Analysis of PWM Signals

Noyan Sevuktekin, Andrew Singer, University of Illinois at Urbana-Champaign, United States

A stochastic analysis for pulse width modulation (PWM) is given. Under a discrete random generator process with independent identically distributed (i.i.d.), continuous, range-limited samples, stochastic models for different PWM signals are proposed. Using randomization of the signal starting point, wide sense stationarity (WSS) of proposed PWM signals are shown. Autocorrelation functions and their corresponding power spectrum densities (PSD) are proposed in terms of the modified complementary cumulative distribution function of i.i.d samples. For the case where the samples are uniformly i.i.d. the proposed autocorrelation functions are tested with simulations.

TP8b1-5

Statistical Data Correction for Unreliable Memories

Christoph Roth, ETH-Zurich, Switzerland; Christoph Struder, Cornell University, United States; Georgios Karakonstantis, Andreas Burg, École Polytechnique Fédérale de Lausanne, Switzerland

In this paper, we introduce a statistical data- correction framework that aims at improving the DSP system performance in presence of unreliable memories. The proposed signal processing framework implements best-effort error mitigation for signals that are corrupted by defects in unreliable storage arrays using a statistical correction function extracted from the signal statistics, a data-corruption model, and an application-specific cost function. An application example to communication systems demonstrates the efficacy of the proposed approach.

TP8b1-6

Sonar Data Compression using Non-Uniform Quantization and Noise Shaping

Lok Wong, Gregory Allen, Brian Evans, University of Texas at Austin, United States

Sonar arrays potentially produce huge amounts of data to be recorded or transmitted over a telemetry system. Compression can reduce the required storage or transmission bandwidth, or allow larger or higher fidelity arrays. We use a dataset of acoustic communication signals received in a lake test and compress it to evaluate the effect of compression on performance. Based on analysis of the dataset, we use non-uniform quantization with a Laplace distribution along with noise-shaped feedback coding. We demonstrate that this sonar data can be compressed from 16-bit to five-bit values with little or no change in performance using our technique.

TP8b1-7

Multilevel Coding for Non-Orthogonal Broadcast

Stephan Pfletschinger, Monica Navarro, Centre Tecnologic de Telecomunicacions de Catalunya, Spain; Christian Ibars, Intel Corporation, United States

This paper defines an information-theoretical framework for non-orthogonal broadcast systems with multilevel coding and gives design guidelines for the rate selection of multiple broadcast streams. This description includes hierarchical modulation and superposition coding with codes defined in a finite field as a special case. We show how multilevel coding can be applied to multiple antennas where, in contrast to most space-time coding and hierarchical modulation schemes, no capacity loss occurs.

TP8b1-8

Dynamic Target Identification and Classification Based on Resonance Topography Grouping

Ananya Sen Gupta, Daniel Schupp, University of Iowa, United States; Ivars Kirsteins, Naval Undersea Warfare Center, United States

We address the long-standing challenge of sonar target identification against weak ground truths and interfering scatter components by harnessing the inherent topographic elements of acoustic scatter. Inherent robustness against ground truth uncertainty allows unknown target discovery when supervised learning is not practical. Specifically, we employ adaptive subspace tracking techniques to localize scatter components, discover topographic signatures within the target scatter response, and thus classify different targets. The false alarm rate is naturally lowered as each target class has a unique scattering response for each wave profile that is ultimately separable against environmental effects and other interference using its topographic signature.

Track C – Networks

Session: TPb8 – Relays, Cognitive, Cooperative, and Heterogeneous Networks

3:30 PM–5:10 PM

Chair: ***Andrew G. Klein,*** *Worcester Polytechnic Institute*

TP8b2-1

A Distributed Algorithm for Energy Saving in Nomadic Relaying Networks

Zhe Ren, BMW Group Research and Technology, Germany; Mahdy Shabeeb, Munich University of Technology, Germany; Slawomir Stanczak, Fraunhofer Institute for Telecommunications Heinrich Hertz Institute, Germany; Peter Fertl, BMW Group Research and Technology, Germany

This extended abstract presents a distributed cell selection algorithm for energy savings in nomadic relaying networks where randomly distributed devices (e.g., parked vehicles) serve as potential relay nodes. Based on broadcasted load information and estimated link quality, the nomadic relays and subsequently the users select access points so to minimize the energy consumption in the network. Furthermore, admission control mechanisms are incorporated at the base stations and nomadic relay nodes to avoid overloading. We prove the convergence of our algorithm and simulation results confirm that the proposed algorithm significantly reduces the energy consumption compared with traditional cell selection algorithms.

TP8b2-2

Instantaneous Relaying for the 3-Way Relay Channel with Circular Message Exchanges

Bho Matthiesen, Eduard A. Jorswieck, Technische Universität Dresden, Germany

The 3-user discrete memoryless multi-way relay channel with circular message exchange and instantaneous relaying is investigated. We first show that this channel is effectively a 3-user interference channel with receiver message side information for every fixed (and instantaneous) relay mapping. Then, we extend the Han-Kobayashi coding scheme to this channel. Finally, we apply these results to Gaussian channels with amplify-and-forward relaying and present numerical results showing the gain of the proposed scheme compared to the state of the art.

TP8b2-3

On the Performance of Hybrid Satellite-Terrestrial Cooperative Networks with Interferences

Min Lin, PLA University of Science and Technology, China; Jian Ouyang, Nanjing University of Posts and Telecommunications, China; Zhu Wei-Ping, Concordia University, Canada

The paper investigates the performance of a hybrid satellite-terrestrial cooperative network (HSTCN), where some terrestrial AF relays are employed to assist the signal transmission from a satellite to a destination, which is corrupted by multiple CCIs. We derive the MGF of the output SINR and present the analytical ASER expression for the considered cooperative system. Moreover, the asymptotic ASER analysis in terms of the diversity order and array gain is also developed. Finally, numerical results are given to demonstrate the validity of the performance analysis and the impacts of shadowing parameters, relay number and CCIs on the considered HSTCN.

TP8b2-4
An Online Parallel Algorithm for Spectrum Sensing in Cognitive Radio Networks

Yang Yang, Technische Universitaet Darmstadt, Germany; Mengyi Zhang, Chinese University of Hong Kong, Hong Kong SAR of China; Marius Pesavento, Technische Universitaet Darmstadt, Germany; Daniel Palomar, Hong Kong University of Science and Technology, Hong Kong SAR of China

We consider in cognitive radio the estimation of the position and transmit power of primary users based on a l1-regularized recursive least-square problem. The power vector is possibly sparse and measurements are only sequentially available. We propose for the first time an online parallel algorithm that is novel in three aspects: i) all elements of the unknown vector variable are updated in parallel; ii) the update of each element has a closed-form expression; and iii) the stepsize is designed to boost the convergence yet it still has a closed-form expression. The convergence property is both theoretically analyzed and numerically consolidated.

TP8b2-5
On the Spatial Spectral Efficiency of ITLinQ

Ratheesh Mungara, Universitat Pompeu Fabra, Spain; Xinchen Zhang, University of Texas at Austin, United States; Angel Lozano, Universitat Pompeu Fabra, Spain; Robert W. Heath Jr., University of Texas at Austin, United States

Device-to-device (D2D) communication has been considered as a potential ingredient of 5G cellular networks. In this paper, we consider the so-called ITLinQ (information-theoretic independent link) scheduling scheme [1] for D2D users operating on a dedicated spectrum with respect to the cellular users and analytically characterize the spectral efficiency achievable by ITLinQ. The analysis relies on a stochastic geometry formulation, which facilitates obtaining compact expressions and provide means to optimally choose system parameters.

TP8b2-6
Time and Frequency Self-Synchronization in Dense Cooperative Networks

Maria Antonieta Alvarez, Bahar Azari, Umberto Spagnolini, Politecnico di Milano, Italy

Dense cooperative network involves communication and coding among multiples uncoordinated nodes, time and frequency synchronization is mandatory to guarantee network operations. Here we propose a novel method to perform time and frequency synchronization in presence of large carrier frequency offsets (CFOs) based on weighted consensus algorithm to reach synchronization in a connected network. Peculiarity is the synchronization frame structure based on a common CAZAC sequence but arranged to decouple CFO from time error in symbol and frame synchronization. Time and frequency synchronization is guaranteed in multi-node interference scenario without the need to assign every node an independent CAZAC sequence.

TP8b2-7
Effect of Cluster Rotation Speed in Coordinated Heterogeneous MIMO Cellular Networks with Proportionally Fair User Scheduling

Hakimeh Purmehdi, Robert Elliott, Witold Krzymien, University of Alberta, Canada; Jordan Melzer, TELUS Communications, Canada

The effect of how often clustering patterns change within a previously proposed rotating clustering scheme on the average achievable downlink rates of a coordinated heterogeneous multicell multiple-input multiple-output (MIMO) system is investigated. Rotating the base station cluster patterns allows users to be nearer the cluster center in one of the patterns. The performance of the system with different cluster rotation rates is evaluated, using a simulated annealing user scheduling algorithm with a proportionally fair metric. Simulations demonstrate there is a maximum speed of rotation, above which negligible further gains in performance are achieved compared to fixed clustering.

TP8b2-8
Relay Selection for AF Wireless Relay Networks in Adverse Communication Environments

Kanghee Lee, Republic of Korea Air Force, Republic of Korea; Visvakumar Aravinthan, Sunghoon Moon, Wichita State University, United States; Jongbum Ryou, Changki Moon, Inha Hyun, Republic of Korea Air Force, Republic of Korea; Sun Jo, Defense Acquisition Program Administrtion of ROK, Republic of Korea

This paper addresses wireless relay networks consisting of a one-source-one-destination pair and N noncooperative relays. An objective of this paper is to analytically derive a closed form of an optimal relay amplifying vector (or matrix) for an amplify-and-forward (AF) wireless relay network under channel uncertainty (CU), jamming, and transmission power constraints at the relays, using the minimum mean square error (MMSE) criterion. In addition, this paper presents an efficient relay-selection strategy using the maximum SNR and minimum MMSE cost function criterions under an adverse wireless communication environment with transmission power constraint at the relays.

Session: TPb8 – Signal Processing Architectures 3:30 PM–5:10 PM

Chair: ***Zain Ul-Abdin,*** *Halmstad University*

TP8b3-1
Hybrid Floating-Point Modules with Low Area Overhead on a Fine-Grained Processing Core

Jon Pimentel, Bevan Baas, University of California, Davis, United States

This paper proposes Hybrid Floating-Point Modules (HFPMs) as a method to improve software floating-point (FP) throughput without incurring the area overhead of hardware floating-point units (FPUs). The proposed HFPMS were synthesized in 65 nm CMOS. They increase throughput over a fixed-point software FP implementation by 3.6x for addition/subtraction, 2.3x for multiplication, and require less area than hardware modules. Nine functionally equivalent FPU implementations using combinations of software, hardware, and hybrid modules are synthesized and provide 1.07-3.34x higher throughput than a software FPU implementation, while requiring 1.08-12.5x less area than a hardware FPU for multiply-add operations.

TP8b3-2
Scalable Hardware-Based Power Management for Many-Core Systems

Bin Liu, Brent Bohnenstiehl, Bevan Baas, University of California, Davis, United States

Due to high levels integration, the design of many-core systems becomes increasingly challenging. Runtime dynamic voltage and frequency scaling (DVFS) is an effective method in managing the power based on performance requirement in the presence of workload variations. This paper presents an on-line scalable hardware-based dynamic voltage frequency selection algorithm, by using both FIFO occupancy and stall information between processors. To demonstrate the proposed solution, two real application benchmarks are tested on a many-core globally asynchronous locally synchronous (GALS) platform. The experimental results shows that the proposed approach can achieve near-optimal power saving under performance constraint.

TP8b3-3
Optimized FPGA Based Implementation of Discrete Wavelet Transform

Amin Jarrah, Mohsin M. Jamali, University of Toledo, United States

Discrete Wavelet Transformation (DWT) has widespread usage in many vital applications. It is used to represent real-life non-stationary signals with high efficiency and also used for de-noising the signal. However, the DWT is computationally intensive. Therefore, Haar Wavelet Transform (HWT) has been implemented on FPGAs by exploiting parallel and pipelining approaches. All dimensions (1-D, 2-D, and 3-D) architectures are implemented and optimized. High level synthesizer from Xilinx used to implement HWT on FPGAs. The throughput of our optimized implementation shows considerable improvement on an un-optimized version.

TP8b3-4
Mapping and Scheduling of Dataflow Graphs - A Systematic Map

Usman Mazhar Mirza, Mehmet Ali Arslan, Gustav Cedersjö, Sardar Muhammad Sulaman, Jörn W. Janneck, Lund University, Sweden

Dataflow is a natural way of modelling streaming applications, such as multimedia, networking and other signal processing applications. In order to cope with the computational and parallelism demands of such streaming applications, multiprocessor systems are replacing uniprocessor systems. Mapping and scheduling these applications on multiprocessor systems are crucial elements for efficient implementation in terms of latency, throughput, power and energy consumption etc. Performance of streaming applications running on multiprocessor systems may widely vary with mapping and scheduling strategy. This paper performs a systematic literature review of available research carried out in the area of mapping and scheduling of dataflow graphs.

TP8b3-5
Dataflow Machines

Jörn W. Janneck, Gustav Cedersjö, Lund University, Sweden; Endri Bezati, Simone Casale Brunet, École Polytechnique Fédérale de Lausanne, Switzerland

This paper presents a model for stream programs aimed at capturing their essential logical structure in a way that is amenable to analysis, composition, and hardware and software code generation. We discuss the properties of the model, and its relationship to a previous effort, actor machines, which it generalizes and which can be viewed as a step in the implementation flow of

dataflow machines. Dataflow machines are motivated by the shortcomings of actor machines when generating highly parallel implementations (such as in hardware), and when composing machines. The paper compares and contrasts the two models with emphasis on these two topics.

TP8b3-6
Replacement Techniques for Improving Performance in Sub-Block Caches
Oluleye Olorode, Mehrdad Nourani, University of Texas at Dallas, United States

Recent advances in processor architecture have led to the introduction of sub-blocking to cache architectures. Sub-blocking reduces the tag area and power overhead in caches without reducing the effective cache size, by using fewer tags to index the full data RAM array. But they suffer from performance degradation due to cache pollution. We propose intelligent sub-block cache replacement policies that use the valid state of individual sub-blocks in replacement decisions at the super-block level. Performance evaluations using Simplescalar toolset show improvement of up to 4.17% in SPEC2006 benchmarks.

TP8b3-7
Dynamic Reconfiguration of FPGA-based Multi-Processor Arrays
James Glenn-Anderson, Supercomputer Systems, Inc., United States

In this paper, the Multi-Processor Array ('MPA') architectural form is augmented with hardware partial reconfiguration on I/D-space memory components. Three major advantages are thus derived; (1) resource constrained extension of the MPA functional envelope, (2) improved performance scaling across processor array order, and (3) maximal parallel processing gain. A supporting analysis reveals the partially reconfigurable MPA ('pr-MPA') exhibits substantial performance benefit when compared with standard SMP architectural forms.

TP8b3-8
Coprime Processing for the Elba Island Sonar Data Set
Vaibhav Chavali, Kathleen Wage, George Mason University, United States; John Buck, University of Massachusetts Dartmouth, United States

Coprime sensor arrays (CSAs) use interleaved uniform line arrays (ULAs) containing a relatively small number of sensors to obtain resolution comparable to a single densely populated ULA. For narrowband CSA processing, each interleaved subarray is beamformed independently, and the resulting outputs are multiplied and averaged over time to obtain the CSA power spectrum. Although the individual subarrays are undersampled, the overall CSA output is not aliased. This paper considers the problem of designing coprime arrays for passive sonar and applies CSA processing to analyze the existing Elba Island data set.

Track D – Signal Processing and Adaptive Systems

Session: TPb8 – Signal Processing Theory and Applications 3:30 PM–5:10 PM

Chair: ***Yue Lu,*** *Harvard University*

TP8b4-1
Prediction of a Bed-Exit Motion: Multi-Modal Sensing Approach and Incorporation of Biomechanical Knowledge
Jun Hao, Xiaoxiao Dai, Amy Stroder, Jun Zhang, Bradley Davidson, Mohammad Mahoor, University of Denver, United States; Neil McClure, OKT Enterprises, United States

This paper aims to answer the following questions: 1) How to detect and predict a bed-exit motion, and 2) How early a bed-exit motion can be predicted before it actually happens.To achieve the above goals we consider the following sensing modalities for observing the human motion during a bed-exit: RGB images, depth images and radio frequency (RF) sensing. Using the measurements from the aforementioned sensing modalities, we investigate different approached to infer information on the human motion. The combination of RGB and depth images significantly enhances the performance of motion recognition.

TP8b4-2

Ultra-Wideband Radar based Human Body Landmark Detection and Tracking with Biomedical Constraints for Human Motion Measuring

Xiaoxiao Dai, Zhichong Zhou, Jun Zhang, Bradley Davidson, University of Denver, United States

In this manuscript, we propose and investigate a methodology for detecting and tracking human body landmarks using ultra-wideband (UWB) radars. The detection of multiple human body landmarks (HBLs) is achieved by motion target indication techniques, and the multi-HBL tracking is accomplished by a novel iterative convex optimization based approach with considerations of biomechanics constraints. It is demonstrated that detection and track of the moving trajectories of two markers are feasible and successfully achieved, and thus, the human arm motion is accurately measured using one UWB radar.

TP8b4-3

Separation of Interleaved Markov Chains

Ariana Minot, Yue Lu, Harvard University, United States

We study the problem of separating interleaved sequences from discrete-time finite Markov chains. Previous work has considered the setting where the Markov chains participating in the interleaving have disjoint alphabets. In this work, we consider the more general setting where the component chains' alphabets can overlap. We formulate the problem as a hidden Markov model (HMM) and develop a deinterleaving algorithm by modifying classical HMM estimation techniques to take advantage of the special structure of our deinterleaving problem. Numerical results verify the effectiveness of the proposed method.

TP8b4-4

Ramanujan Subspaces and Digital Signal Processing

P. P. Vaidyanathan, California Institute of Technology, United States

Ramanujan-sums have in the past been used to extract hidden periods in signals. In a recent paper [13] it was shown that for finite duration (FIR) sequences, the traditional representation is not suitable. Two new types of Ramanujan-sum expansions were proposed for the FIR case, each offering an integer basis, and applications in the extraction of hidden periodicities were developed. Crucial to these developments was the introduction of Ramanujan spaces in [13]. The aim of this paper is to develop some properties of these subspaces in the context of signal processing. This includes periodicity properties, autocorrelation properties, and development of an integer-based projection operator for these spaces. An application in the denoising of periodic signals is also demonstrated.

TP8b4-5

Asynchronous Discrete-time Signal Processing with Molecular Reactions

Sayed Ahmad Salehi, Marc Riedel, Keshab K. Parhi, University of Minnesota, United States

We present a new methodology to synthesize molecular reactions for DSP computations that produce time-varying quantities of molecules as a function of time-varying input quantities. DSP structures include delay elements which need to be synchronized by a clock signal. This paper demonstrates an approach to synthesize molecular reactions to implement DSP operations without requiring a clock signal. In the proposed approach, each delay and output variables are mapped to two types of molecules. The scheduling of the reactions is controlled by absence indicators, i.e., signals transfer according to the absence of other signals. All computations are scheduled in four phases.

TP8b4-6

Sequential Prediction of Individual Sequences in the Presence of Computational Errors

Mehmet Donmez, Andrew Singer, University of Illinois at Urbana Champaign, United States

We study the performance of a sequential linear prediction system built on nanoscale beyond-CMOS circuit fabric that may introduce in computation. We propose a new sequential linear prediction algorithm under a mixture-of-experts framework that performs satisfactorily in the presence of computational errors. We introduce a worst-case approach to model the computational errors, where we view erroneous circuit fabric as an adversary that perturbs the prediction algorithm to heavily deteriorate its performance. We demonstrate that our algorithm achieves uniformly good performance under the worst-case error approach in an individual sequence manner

TP8b4-7
A Scalable Feature Learning and Tag Prediction Framework for Natural Environment Sounds
Prasanna Sattigeri, Arizona State University, United States; Jayaraman Thiagarajan, Lawrence Livermore National Laboratory, United States; Mohit Shah, Arizona State University, United States; Karthikeyan Ramamurthy, IBM Research, United States; Andreas Spanias, Arizona State University, United States

Building feature extraction approaches that can effectively characterize natural environment sounds is challenging due to the dynamic nature. In this paper, we develop a framework for feature extraction and obtaining semantic inferences from such data. In particular, we propose a new pooling strategy for deep architectures, that can preserve the temporal dynamics in the resulting representation. By constructing an ensemble of semantic embeddings, we employ an l1-reconstruction based prediction algorithm for estimating the relevant tags. We evaluate our approach on challenging environmental sound recognition datasets, and show that the proposed features outperform traditional spectral features.

TP8b4-8
Extending Coherence for Optimal Detection of Nonstationary Harmonic Signals
Scott Wisdom, University of Washington, United States; James Pitton, Applied Physics Laboratory and University of Washington, United States; Les Atlas, University of Washington, United States

This paper describes an optimal detector for nonstationary harmonic signals that unifies several classic approaches. The detector's performance is further improved by using a novel method for extending the coherence time of such signals. The method applies a transformation to a noisy signal that attempts to fit a simple model to the signals's slowly changing fundamental frequency over the analysis duration. By matching the change in the signal's fundamental frequency, analysis is more coherent with the signal over longer durations, which allows the use of longer windows and thus improves detection performance. Preliminary results show performance improvements on synthetic data.

Track B – MIMO Communications and Signal Processing
Session: WAa1 – MIMO Design for mmWave Systems
Chair: ***Zhouyue Pi,*** *Samsung*

WA1a-1 8:15 AM
A Tractable Model for Rate in Noise Limited mmWave Cellular Networks
Sarabjot Singh, Mandar Kulkarni, Jeffrey Andrews, University of Texas at Austin, United States

The use of millimeter wave (mmWave) spectrum for future cellular systems can be made possible with the use of highly directional beamforming (massive MIMO) and dense base station deployments. Due to the higher frequencies in use, however, the mmWave broadband networks would exhibit fundamentally different behaviors compared to conventional microwave cellular systems. Prominently, interference and path loss models and the corresponding effect on SINR and rate need to be re-examined. We propose a general and tractable model to capture and analyze the key distinguishing features of a mmWave cellular broadband system, and characterize the SINR and rate distribution in such networks. The analytical insights are validated by simulations using real building locations in major metropolitan areas in conjunction with empirically supported mmWave path loss models. Using both the proposed model and simulations, it is shown that unlike the interference limited nature of 4G cellular networks, mmWave cellular networks would tend to be noise limited and the coverage heavily relies on a user being able to received sufficient power from the serving BS. Further, the cell edge rates are shown to be limited by the base station density and are not necessarily improved by increasing the downlink bandwidth of the system.

WA1a-2 8:40 AM
MIMO Designs for mmWave Wireless LAN Systems
Sridhar Rajagopal, Shadi Abu-Surra, Sudhir Ramakrishna, Rakesh Taori, Samsung Research America, United States

In this paper, we explore unique aspects of MIMO designs for mmWave wireless LAN systems, focusing on MIMO feasibility and protocol implications. We study the spectral efficiency gains achievable by using 2x2 and 4x4 MIMO with dual polarization in an indoor environment. We show that MIMO gains (for SU-case) are limited beyond 2x2 MIMO and that fine beamforming is essential for capacity gains under MIMO. Finally, we provide efficient association and beamforming techniques for SU/MU-MIMO enabling greater number of STAs to associate and refine beams in a given amount of time compared to IEEE 802.11ad.

WA1a-3 9:05 AM

Analysis of Millimeter Wave Cellular Networks with Overlaid Microwave Base Stations

Tianyang Bai, Robert W. Heath Jr., University of Texas at Austin, United States

The use of millimeter wave (mmWave) spectrum for the cellular access channels is promising for 5G networks. Cellular systems that support mmWave will likely support microwave frequencies as well to achieve the complementary benefits from both bands. This paper proposes a stochastic geometry framework for the coverage and rate analysis for multi-band cellular networks, where mmWave networks are overlaid with macro-microwave base stations. The system model incorporates important differentiating characteristics in mmWave and microwave systems. Distributions of the signal-to-interference-and-noise ratio (SINR) and achievable rate are derived under certain association rules and compared with the performance of single band microwave and mmWave systems. Compared with prior work, the proposed model can be used to evaluate the performance of indoor users as well. The results show that overlaid microwave base stations is useful to avoid coverage holes in mmWave networks and provide good performance at indoor users.

WA1a-4 9:30 AM

Initial Beamforming for mmWave Communications

Vip Desai, Philippe Sartori, Weimin Xiao, Anthony Soong, Lukasz Krzymien, Huawei Technologies Co., Ltd., United States; Ahmed Alkhateeb, University of Texas at Austin, United States

Cellular systems were designed for frequencies in the microwave band but will operate up to 6 GHz. To meet the increasing demands, deployments above 6 GHz are envisioned. As these systems migrate, channel characteristics impact coverage range. To increase coverage, beamforming can be used. Because cellular procedures enable beamforming after a user establishes access, new procedures are needed to enable beamforming during discovery. This paper discusses several issues that to resolve for access at mmWave frequencies, and presents solutions which are verified by computer simulations. It is shown that reliable network access and satisfactory coverage can be achieved.

Track B – MIMO Communications and Signal Processing

Session: WAb1 – Massive MIMO II

Chair: ***David J. Love,*** *Purdue University*

WA1b-1 10:15 AM

A Multistage Linear Receiver Approach for MMSE Detection in Massive MIMO

Ting Li, Sujeet Patole, Murat Torlak, University of Texas at Dallas, United States

A key property of Massive MIMO is the orthogonality among channels when the number of antennas at the base station becomes large. When using MMSE detection method, it is suggested that instead of dealing with the true matrix inversion operation, we can simply approximate the matrix inverse by the inversion of its diagonal elements. However, we show in this paper that this diagonal inversion will not perform well and we propose a low-complexity detector based on Multistage Linear Receiver which performs well even with low number of stages and accounts for lower computation complexity.

WA1b-2 10:40 AM

Beamforming-Based Spatial Precoding in FDD Massive MIMO Systems

Ming-Fu Tang, Meng-Ying Lee, Borching Su, National Taiwan University, Taiwan; Chia-Pang Yen, Industrial Technology Research Institute, Taiwan

In this paper, we proposed a new method for downlink precoding in massive MIMO systems using frequency division duplex (FDD). By taking advantage of beamforming, the proposed method not only reduces the downlink training signal overhead but also preserves the multiplexing gain. Preliminary simulation results show that the proposed method has the competitive bit error rate performance comparing with the conventional method in MIMO systems under certain channels.

WA1b-3 **11:05 AM**

Asymmetric Distributed Space Frequency Coded Cooperative Network for Large Scale MIMO

Bhagyashri Honrao, Chirag Warty, Shikha Nema, SNDT University, India

In this paper, the design of distributed space frequency codes (DSFCs) implementing the decode-and-forward (DF) and Amplify and Forward (AF) protocol for asymmetric case is considered. It designed to achieve the frequency and cooperative diversities. To achieve the maximal diversity order the source and relay node coding is considered. For DF protocol, a two-stage coding scheme, with source and relay nodes coding, is proposed. We derive sufficient conditions at the source and relay nodes to achieve full diversity of order NL. For AF protocol, a structure for DSF coding is proposed.

Track A – Communications Systems

Session: WAa2 – 5G and Energy Efficient Cellular Networks

Chair: ***Jinkang Zhu,*** *University of Science and Technology of China*

WA2a-1 **8:15 AM**

Traffic Aware Offloading for BS Sleeping in Heterogeneous Networks

Shan Zhang, Sheng Zhou, Zhisheng Niu, Tsinghua University, China

Due to the rapid development of wireless technology, a long-term coexistent of different cellular systems (namely GSM, 3G and LTE) is expected, which has made the cellular networks heterogeneous. Heterogeneous networks (HetNet) are promising to boost the network capacity, but also bring huge power consumption. Base station (BS) sleeping is considered to be an effective way to solve this problem. In the multi-layer HetNets, idle BSs can be freely turned off to save energy since their original coverage can be guaranteed by other layers. Besides, more BSs can go into idle state to sleep when traffic offloading is conducted. In this paper, we explore how much energy can be saved through BS sleeping under time varying traffic load, where GSM and OFDMA systems coexist and differential services are offered. A tractable location-based traffic offloading and BS sleeping mechanism is adopted for theoretical analysis. The analytical results of energy saving gain are obtained, which are evaluated by extensive simulations. Numerical results reveal the effectiveness of BS sleeping.

WA2a-2 **8:40 AM**

A Survey on 5G New Waveform: From Energy Efficiency Aspects

Shunqing Zhang, Xiuqiang Xu, Yiqun Wu, Lei Lu, Yan Chen, Huawei Technologies Co., Ltd., China

With the aim of delivering any information in anytime and anywhere, 5G wireless communication networks become a fashion topic in the wireless research areas and new waveform, as one of the key enabling technologies in 5G physical layer, attracts growing research attentions in recent years. In this paper, we mainly focus on surveying the waveforms from the energy efficiency point of view. Two categories of waveforms are analyzed and the related implementation issues are discussed. Moreover, we implement the above waveforms using software-defined radio based prototype platform and generate the measurement results for the energy efficiency comparison.

WA2a-3 **9:05 AM**

Evolution of LTE and new Radio Access Technologies for FRA (Future Radio Access)

Hidetoshi Kayama, Huiling Jiang, DOCOMO Beijing Communications Laboratories Co. Ltd., China

To meet the requirements for mobile traffic increase, LTE and LTE-A services have been launched by many mobile operators in worldwide. However, according to the ongoing development of terminals and mobile cloud services, further enhancement of channel capacity is required. Thus the discussion toward 5G technologies is becoming hot and hot in academe and mobile communication industry now. In this talk, current situation of LTE deployment by NTT DOCOMO Japan, including area deployment and spectrum assignment, will be introduced first. Then new technical trend for FRA (Future Radio Access) will be presented. Here, small cell deployment and its interwork with macro-cell is regarded as one of promising ways for increasing channel capacity while maintaining mobility support. From radio access technologies' points of view, advanced interference mitigation and non-orthogonal multiple access (NOMA) are likely to be key issues for future systems. As to massive-MIMO, some technical issues such as overhead reduction are left for open issues.

WA2a-4 **9:30 AM**

A Novel Cell-Interference Model and Performance Analysis of the Future Wireless Networks

Jinkang Zhu, Haibao Ren, University of Science and Technology of China, China

A novel quantified cell-interference depth model is proposed in this paper, to study the interference properties and networking performance of the future wireless networks. The proposed model can be used to describe precisely the interference varies with the cell depth entered. And then we derive the calculation formulas of the cell spectral efficiency and the energy efficiency, and analyze numerically the achievable performance of the cellular networks. This research will provide the theoretical basis for the architecture design of the future wireless networks.

Track F – Biomedical Signal and Image Processing

Session: WAb2 – Mobile Health

Chair: ***Mi Zhang,*** *Cornell University*

WA2b-1 **10:15 AM**

On Outlier Detection in R-R Intervals from ECG Data Collected in the Natural Field Environment

Rummana Bari, Santosh Kumar, University of Memphis, United States

ECG is useful in inferring several health states, e.g., detection of stress or illicit drug use. Detecting outliers in R-R intervals is critical to reliably inferring health status in field. Existing methods for outlier detection are based on data collected from lab. This paper presents a new outlier detection method for the field environment. Evaluation on real-life data shows that this new method detects outliers in R-R intervals with an accuracy of 99.04% in lab and 97.8% in field.

WA2b-2 **10:40 AM**

Patient-Centric On-Body Sensor Localization in Smart Health Systems

Ramyar Saeedi, Hassan Ghasemzadeh, Washington State University, United States

Abstract – In this paper, we introduce a localization algorithm to continuously detect location of on-body sensors. Our approach allows patients to wear sensors on different body segments they are most comfortable with. The algorithm identifies sensor location automatically as the patient uses the system in a normal setting. The aim of our algorithm is finding the location of sensors with the minimum amount of intrusion, and dependence for sensor installation.

WA2b-3 **11:05 AM**

Making Sense of Personal Data in Clinical Settings

Harinath Garudadri, University of California, San Diego, United States

In this presentation, we make a distinction between the data collected inside hospital walls for clinical use and the data generated by personal and wearable devices in free-living conditions aimed at promoting lifestyle and behavioural changes. We observe that adoption of personal data in clinical settings has been slow compared to the vision put forward by thought leaders. Based on our interactions with clinical community, there are many opportunities to improve the quality of care and/or reduce the cost of healthcare delivery by extending the care-giver's reach beyond the hospital walls, provided (i) such care is comparable to current standard of care and (ii) does not overly burden the system from delivering current standard of care. Regarding (i), wireless Electrocardiograph (ECG) is an excellent example to illustrate the technical innovations required to meet the current standard of care. We will describe low power signal processing techniques to mitigate channel errors and motion artifacts in wireless ECG. We will then present a platform we used to demonstrate "wired" quality in the presence of channel errors and motion artifacts using industry standards adopted by the Food and Drugs Administration (FDA) for current ECG devices. Regarding (ii), we are working closely with the clinical community to incorporate such innovations in their workflows with minimal impact to current practices, and enable care beyond hospital walls. Our initial use-cases include at-home care during coronary disease convalescence and remote monitoring to reduce readmission rates by enabling timely, and less intensive clinical interventions.

Session: WAa3 – Sparse Learning and Estimation

Chair: ***Ali Pezeshki,*** *Colorado State University*

WA3a-1 8:15 AM

Sparse Bayesian Learning Using Approximate Message Passing

Maher Al-Shoukairi, Bhaskar Rao, University of California, San Diego, United States

We use the approximate message passing framework (AMP)[1] to address the problem of recovering a sparse vector from undersampled noisy measurements. We propose an algorithm based on Sparse Bayesian learning (SBL)[2]. Unlike the original EM based SBL that requires matrix inversions, the proposed algorithm has linear complexity, which makes it perfect for large scale problems. Compared to other message passing techniques, the algorithm requires fewer approximations, due to the Gaussian prior assumption on the original vector. Numerical results show that the proposed algorithm has comparable and in many cases better performance than existing algorithms despite significant reduction in complexity.

WA3a-2 8:40 AM

Hierarchical Bayesian Approach for Jointly-Sparse Solution of Multiple-Measurement Vectors

Mohammad Shekaramiz, Todd K. Moon, Jacob H. Gunther, Information Dynamics Laboratory / Utah State University, United States

Many signals can be well-estimated via a few supports under some basis. Previous work for finding such sparse representations is mostly based on greedy Orthogonal-Matching-Pursuit and Basis-Pursuit algorithms. Though they work pretty well for Single-Measurement-Vectors, the sparse solution exactness reduces when having Multiple-Measurement-Vectors. This problem has applications such as Xampling's support recovery problem. Here, rather than using such algorithms we propose a hierarchical Bayesian model which provides more exact solutions. Furthermore, we modify the model to account for clumps of the neighbor supports in the solution. Several examples are considered to illustrate the merit of proposed model compared to OMP.

WA3a-3 9:05 AM

Dictionary Approaches For Identifying Periodicities in Data

Srikanth Venkata Tenneti, P. P Vaidyanathan, California Institute of Technology, United States

In this paper, we propose a number of high dimensional representations for periodic signals and use them for identifying their periodic properties. Apart from estimating the unknown period of a signal, we target the problem of periodic decomposition - that is to express the given signal as a sum of signals with periods as small as possible. Our high dimensional representations are inspired from the DFT based Farey dictionary that was introduced in [1], where the problem of periodic decomposition was looked at in terms of finding sparse representations for periodic signals. We take an alternate view point in this paper by showing that periodic decomposition can instead be framed as a data-fitting problem. This allows us to design a simple l_2 norm minimization framework with closed form solutions and several orders of magnitude faster computations than finding the sparse representations with the Farey dictionary. We also generalize the Farey dictionary to construct other dictionaries with much simpler structures that are an order of magnitude faster even for the sparsity based l_1 techniques. We find that dictionaries constructed using the recently proposed Ramanujan Periodicity Transforms [2] provide the best trade-off between complexity and noise immunity, both for the l_1 and l_2 methods.

WA3a-4 9:30 AM

An Asymptotic Maximum Likelihood Estimator for the Period of a Cyclostationary Process

David Ramírez, Peter J. Schreier, University of Paderborn, Germany; Javier Vía, Ignacio Santamaría, University of Cantabria, Spain; Louis L. Scharf, Colorado State University, United States

We derive the maximum likelihood (ML) estimator of the cycle period of a univariate cyclostationary process. Transforming the univariate cyclostationary process into a vector-valued wide sense stationary process allows us to obtain the structure of the covariance matrix, which is required for the likelihood. This covariance matrix is block-Toeplitz, but the block size depends on the unknown cycle period. Therefore, we sweep the block size and obtain the ML estimate of the covariance matrix. Since there are no closed-form ML estimates of block-Toeplitz matrices, we resort to the frequency-domain likelihood. Finally, a numerical example shows the utility of the estimator.

Track D – Signal Processing and Adaptive Systems

Session: WAb3 – Advances in Statistical Learning

Chair: ***Kobi Cohen,*** *University of Illinois at Urbana-Champaign*

WA3b-1 10:15 AM

Quasicontinuous State Hidden Markov Models Incorporating State Histories

Todd K. Moon, Jacob H. Gunther, Utah State University, United States

The Markovity intrinsic in conventional hidden Markov models (HMMs) does not necessarily match the statistical structure of many real signals. Even though many signals have long-term dependencies which may not be represented by the Markovity, HMMs are used because they provide a well-known trainable model. In this paper, we generalize the concept of the HMM state to include the history of states leading to a state, while still limiting the number of basic states to a finite number. This expanded view of the state is efficiently represented using real-numbered states, where the fractional portion provides a variable which represents state histories and which can govern path-dependent model parameters, and the integer portion is the conventional state label. State sequence estimation is accomplished using a straightforward extension of the Viterbi algorithm. Parameters estimation for state transition probabilities and output distributions is presented.

WA3b-2 10:40 AM

A Classification Centric Quantizer for Efficient Encoding of Predictive Feature Errors

Scott Deeann Chen, Pierre Moulin, University of Illinois at Urbana-Champaign, United States

A joint compression and classification system optimizes visual fidelity and classification accuracy under a bit rate constraint. Previous work however does not fully utilize the knowledge of the target classification task while encoding. Therefore, we propose a classification centric quantizer (CCQ), which is tailored to preserve classification-related information in a joint compression and classification system, and its learning algorithm. We apply and evaluate the CCQ on a scene classification problem and compare results to previous work. We also studied the performance of using gradient descent and stochastic gradient descent in the learning algorithm.

WA3b-3 11:05 AM

Time-Varying Stochastic Multi-Armed Bandit

Sattar Vakili, Qing Zhao, Yuan Zhou, University of California, Davis, United States

In the classic stochastic multi-armed bandit (MAB) problem, there is a given set of arms, each generating i.i.d. rewards according to a fixed unknown distribution. The objective is an online learning algorithm for sequential arm selection that minimizes regret defined as the total reward loss over a time horizon compared with the ideal scenario of known reward models. In this paper, we consider a time-varying MAB problem where the unknown reward distribution of each arm can change arbitrarily over time. We obtain a lower bound on the regret order and demonstrate that an online learning algorithm achieves this lower bound.

Track A – Communications Systems

Session: WAa4 – Physical Layer Security II

Chair: ***Pin-Hsun Lin,*** *TU Dresden*

WA4a-1 8:15 AM

Investigation of Secure Wireless Regions Using Configurable Beamforming on WARP platform

Yuanrui Zhang, Queen’s University Belfast, United Kingdom; Bei Yin, Rice University, United States; Roger Woods, Queen’s University Belfast, United Kingdom; Joseph R. Cavallaro, Rice University, United States; Alan Marshall, University of Liverpool, United Kingdom; Youngwook Ko, Queen’s University Belfast, United Kingdom

This paper presents a novel approach to network security against passive eavesdroppers. By configuring antenna array beam patterns to transmit the data to specific regions, it is possible to create defined regions of coverage for targeted users. By adapting antenna configuration according to the intended user’s channel state information, the vulnerability of eavesdropping is reduced. In this paper, we present the application of our concept to 802.11n networks where an antenna array is employed at the access point. A range of antenna configurations (from small-scale to large-scale) are investigated by simulation and realized using the Wireless Open-Access Research Platform.

WA4a-2 8:40 AM

Wiretap-Channels with Constrained Active Attacks

Carsten Rudolf Janda, Christian Scheunert, Eduard A. Jorswieck, Dresden University of Technology, Germany

We calculate an achievable secrecy rate for the Wiretap Channel with an active eavesdropper. We consider the replacement and jamming attack explicitly, when imposing different constraints on the jamming sequence. The eavesdropper's optimal strategy is to disturb each symbol equiprobable in the former case, or to jam each symbol with the same jamming power in the latter case. The eavesdropper's replacement attack can be modeled as an additional Binary Symmetric Channel. If the attacker is able to induce a channel corruption which corresponds to his own channel's degradedness or which is even worse, no positive secrecy rate is achievable.

WA4a-3 9:05 AM

Secrecy Rate Maximization for Information and Energy Transfer in MIMO Beamforming Networks

Jens Steinwandt, Ilmenau University of Technology, Germany; Sergiy Vorobyov, Aalto University, Finland; Martin Haardt, Ilmenau University of Technology, Germany

Consider a MIMO broadcast system, where a multi-antenna base station transmits information and energy simultaneously to a multi-antenna information receiver (IR) and a number of multi-antenna energy receivers (ERs). In this paper, we address the beamforming design problem that maximizes the secrecy rate subject to an energy harvesting constraint and a total power constraint. The corresponding optimization problem is a difference of convex functions programming problem (DC), which is generally non-convex. However, based on semidefinite-relaxation, we propose an alternating optimization strategy to tackle this problem and provide simulation results.

WA4a-4 9:30 AM

Everlasting Secrecy in Disadvantaged Wireless Environments against Sophisticated Eavesdroppers

Azadeh Sheikholeslami, Dennis Goeckel, Hossein Pishro-nik, UMASS-Amherst, United States

Secure communication over a wireless channel in the presence of a passive eavesdropper is considered. We present a method to exploit inherent vulnerabilities of the eavesdropper's receiver through the use of "cheap" cryptographically-secure key-bits for jamming, which only need be kept secret from Eve for the (short) transmission period, to obtain information-theoretic (i.e. everlasting) secret bits at Bob. The achievable secrecy rates for different settings are evaluated. Among other results, it is shown that, even when the eavesdropper has perfect access to the output of the transmitter, the method can still achieve a positive secrecy rate.

Track A – Communications Systems

Session: WAb4 – Coding and Decoding

Chair: ***James A. Ritcey,*** *University of Washington*

WA4b-1 10:15 AM

Noisy Belief Propagation Decoder

Chu-Hsiang Huang, Yao Li, Lara Dolecek, University of California, Los Angeles, United States

This paper analyzes an LDPC Belief Propagation (BP) decoder on noisy hardware and proposes a robust decoder implementation. We develop a Gaussian approximate density evolution for noisy BP decoders, and find that perfect decoding is achievable for noisy BP decoders if the message representations are of arbitrarily high precision. Noisy BP decoding thresholds are derived for various regular LDPC codes. We propose an averaging BP decoder by averaging over the messages in all iterations. Simulation results demonstrate that the averaging BP decoder significantly reduces the residual error rates when compared with the nominal BP decoder.

WA4b-2 10:40 AM

A Low-Complexity Improved Successive Cancellation Decoder for Polar Codes

Orion Afisiadis, Alexios Balatsoukas-Stimming, Andreas Burg, École Polytechnique Fédérale de Lausanne, Switzerland

In this extended abstract, we describe a new SC-based decoding algorithm for polar codes, called flip SC. Flip SC can provide significant improvements in terms of frame error rate with respect to SC decoding, while preserving its memory complexity. Moreover, the computational complexity of flip SC is practically equal to that of SC decoding in the waterfall region.

WA4b-3 **11:05 AM**

Differential Trellis Coded Modulation with State Dependent Mappings

Ruey-Yi Wei, National Central University, Taiwan; James Ritcey, University of Washington, United States

Trellis Coded Modulation is an important bandwidth-efficient coded modulation for wireless channels. To apply this to noncoherent channels in which a phase reference is not available, we use differential encoding (DE). This allows non-coherent detection at the receiver. We propose a novel trellis coding scheme for DE, or differential trellis coded modulation (DTCM). DTCM is trellis coded modulation (TCM) with DE defined by states, where distinct trellis states will usually have distinct DE functions. We propose design methods for DE functions for use with noncoherently non-catastrophic DTCM. Further, for 8PSK signals, set partitioning is proposed and trellis diagrams of DTCM are designed. Their advantage over DPSK is confirmed by our simulation results.

Track C – Networks

Session: WAa5 – Information Processing for Social and Sensor Networks

Chair: ***Nadya Bliss,*** *Arizona State University*

WA5a-1 **8:15 AM**

Fourier Transform for Signals on Dynamic Graphs

Arash Golibagh Mahyari, Selin Aviyente, Michigan State University, United States

Signal processing on graphs offers a new way of analyzing multivariate signals. In most applications involving multiple signals from different sources, the relationships among the sources generating the multivariate signals are not uniform. These different configurations of sources can be captured by weighted graphs where the nodes are the sources and the edges indicate the relationships. Classical signal processing concepts need to be adapted to these signals on graphs. The current work assumes the stationarity of these relationships across time. In this paper, we propose a graph Fourier transform for signals on dynamic graphs, where the relationships vary over time.

WA5a-2 **8:40 AM**

Anomalous Subgraph Detection in Publication Networks: Leveraging Truth

Nadya Bliss, Manfred Laubichler, Arizona State University, United States

Analysis of social networks has potential to provide insight to wide range of applications. As datasets continue to grow, a key challenge is lack of existing truth models. Unlike traditional signal processing, where models of truth and background data exist and are often well defined, these models are commonly lacking in social networks. This paper presents a transdisciplinary approach of mitigating this challenge by leveraging research in emergence of innovation together with a novel signal processing for graphs algorithmic framework, allowing rigorous study of innovation patterns in publication networks.

WA5a-3 **9:05 AM**

Identifying Congestion in Software-Defined Networks

Thomas Parker, Jamie Johnson, Murali Tummala, John McEachen, James Scrofani, Naval Postgraduate School, United States

Software-defined networks (SDN) are an emerging technology that offers to simplify networking devices by centralizing the network layer functions and allowing adaptively programmable traffic flows. We propose using spectral graph theory methods to identify and locate congestion in a network. The analysis of the balanced traffic case yields an efficient solution for congestion identification. The unbalanced case demonstrates a distinct drop in connectivity that can be used to determine the onset of congestion. The eigenvectors of the Laplacian matrix are used to locate the congestion and achieve effective graph partitioning.

WA5a-4 **9:30 AM**

Vulnerability of CPS inference to DoS attacks

Mohammadreza Doostmohammadian, Usman A. Khan, Tufts University, United States

We study distributed inference of Cyber Physical Systems (CPS) subject to Denial of Service (DoS) attacks. For the purposes of inference, we assume the physical-layer in the CPS is monitored by a cyber-layer. Under a DoS attack, an adversary may disrupt the sensor network monitoring the system either by attacking the underlying communication or sensors. We investigate countermeasures and CPS resiliency to such attacks and show that the rank-deficiency of the physical system increases the prevalence of hubs in the cyber-layer, and consequently, the vulnerability to adversary attacks. We provide a real-world power system monitoring application to illustrate our results.

Track H – Speech, Image and Video Processing

Session: WAb5 – Document Processing and Synchronization

Chair: ***Olgica Milenkovic,*** *University of Illinois at Urbana-Champaign*

WA5b-1 10:15 AM

Synchronizing Ordinal Data over Noisy Channels

Han Mao Kiah, Lili Su, Olgica Milenkovic, University of Illinois at Urbana-Champaign, United States

We consider the novel problem of synchronizing rankings at remote locations connected by a noisy two-way channel. Such synchronization problems arise when items in the data are distinguishable, as is the case for playlists, tasklists, crowdvotes and recommender systems rankings. In our model, we assume data edits in the form of deletions and translocations, and communication errors introduced by symmetric q-ary channels. Our protocols are order-optimal with respect to genie-aided methods.

WA5b-2 10:40 AM

Efficient Synchronization of Files in Distributed Storage Systems

Salim El Rouayheb, Illinois Institute of Technology, United States; Sreechakra Goparaju, Princeton University, United States; Han Mao Kiah, Olgica Milenkovic, University of Illinois at Urbana-Champaign, United States

We consider the problem of synchronizing data in distributed storage systems under an edit model that includes deletions and insertions. We present two modifications of MDS and regenerating codes that allow updates in the parity-check values to be performed with low communication complexity and with low storage overhead. Our main contributions are novel protocols that work for both hot and semi-static data, and novel update methods that rely on permutation, Vandermonde and Cauchy matrices.

WA5b-3 11:05 AM

Efficient File Synchronization: Extensions and Simulations

Clayton Schoeny, Nicolas Bitouze, Frederic Sala, Lara Dolecek, University of California, Los Angeles, United States

We study the synchronization of two files X and Y at two distant nodes A and B that are connected through a two-way communication channel. We previously proposed a synchronization protocol for reconstructing X at node B with exponentially low probability of error. We have proven the order-wise optimality of the protocol where the binary file Y is the original binary file X modified through iid insertion and deletion edits. In this paper, we expand on previous results by presenting experimental results from numerous scenarios including different types of files and a variety of realistic error patterns. In addition, we introduce novel improvements to the synchronization protocol to further increase efficiency.

Track D – Signal Processing and Adaptive Systems

Session: WAa6 – Adaptive Signal Design and Analysis

Chair: ***Antonia Papandreou-Suppappola,*** *Arizona State University*

WA6a-1 8:15 AM

Eigen-Basis Analysis of Expected Cumulative Modulus for Constrained Signal Design

Aaron Jones, Air Force Research Laboratory, United States; Brian Rigling, Wright State University, United States; Muralidhar Rangaswamy, Air Force Research Laboratory, United States

Radar waveforms require a constant modulus (constant amplitude) transmit signal to exploit the available transmit power. However, recent hardware advances have forced a re-examination of this assumption to quantify the impact of modulus perturbation from phase only signals. In this paper, we express signal modulus in terms of an eigen-spectrum obtained from an eigenvalue distribution that mimics, in the limit of large data, the eigen-spectrum of an interference and noise covariance matrix for radar data.

WA6a-2 8:40 AM

Characterization of Information in Phase of Radar Range Profiles

Linda Moore, Air Force Research Laboratory / University of Dayton, United States; Brian Rigling, Wright State University, United States; Robert Penno, University of Dayton, United States

This work characterizes the information in the phase of radar range profiles with respect to the estimation of features of an unknown target present in the measured signal. A physics-based high-frequency parametric model is employed to describe the radar backscatter. Information is quantified by the error standard deviation of target parameter estimates from noisy radar signals with phase either included or discarded. Information in phase is shown to provide a factor of two increase in achievable target position estimation for X-band signals. In addition, the inclusion of phase for target parameter estimation enables improved discrimination of frequency-dependent scattering characteristics.

WA6a-3 9:05 AM

Radar Tracking Waveform Design in Continuous Space and Optimization Selection Using Differential Evolution

Antonia Papandreou-Suppappola, Bryan Paul, Daniel Bliss, Arizona State University, United States

Waveform design that allows for a wide variety of chirps has proven benefits. However, dictionary based optimization is limited and gradient search methods are often intractable. A new method is proposed using differential evolution to design cubic chirps with coefficients constrained to the 3D unit sphere. Nonlinear functions sufficiently approximated by a third order Maclaurin series can be represented in this chirp space. Cascaded integrator methods for generating polynomial chirps allow for practical implementation in real world systems. While simplified tracking models and finite waveform dictionaries have information theoretic results, we explore 2D tracking continuous waveform design in cluttered environments.

WA6a-4 9:30 AM

Reduced Rank Adaptive Filtering in Impulsive Noise Environments

Hamza Soury, King Abdullah University of Science and Technology (KAUST), Saudi Arabia; Karim Abed-Meraim, Polytech Orleans, France; Mohamed-Slim Alouini, King Abdullah University of Science and Technology (KAUST), Saudi Arabia

An impulsive noise environment is considered in this paper. A new aspect of signal truncation is deployed to reduce the harmful effect of the impulsive noise to the signal. A full rank direct solution is derived followed by an iterative solution. The reduced rank adaptive filter is presented in this environment by using two methods for rank reduction, while the minimized objective function is defined using the Lp norm. The results are presented and the efficiency of each method is discussed.

Track C – Networks

Session: WAb6 – Distributed Detection and Optimization

Chair: ***Andrea Simonetto,*** *Delft University of Technology*

WA6b-1 10:15 AM

Distributed Detection for Wireless Sensor Networks with Fusion Center under Correlated Noise

Alireza S. Behbahani, Ahmed M. Eltawil, Hamid Jafarkhani, University of California, Irvine, United States

In this paper, we study a binary distributed detection problem under correlated noise by using wireless sensors and a fusion center (FC) with one antenna where the channel is a coherent multiple access. In order to decide between the two hypotheses, we design sensors to maximize the error exponent derived based on minimizing probability of error for Bayesian detection subject to network power constraint. We provide a closed form solution for the sensor encoders under correlated noise at the sensors. Furthermore, the effect of noise correlation at the sensors is investigated. Finally, simulations are provided to verify the analysis.

WA6b-2 10:40 AM

Distributed Asynchronous Time-Varying Constrained Optimization

Andrea Simonetto, Geert Leus, Delft University of Technology, Netherlands

We devise a distributed asynchronous gradient-based algorithm to enable a network of computing and communicating nodes to solve a constrained discrete-time time-varying convex optimization problem. Each node updates its own decision variable only once every discrete time step. Under some assumptions (strong convexity, Lipschitz continuity of the gradient, persistent excitation), we prove the algorithm's asymptotic convergence in expectation to an error bound whose size is related to the variability in time of the optimization problem. Moreover, the convergence rate is linear.

WA6b-3 11:05 AM

M-ary Distributed Detection in the Presence of Channel Estimation Error

Zahra Hajibabaei, Azadeh Vosoughi, University of Central Florida, United States

We consider a wireless sensor network, consisting of N sensors and a FC, tasked with distributed classification of M Gaussian sources. Each sensor makes an M-ary decision and maps it to binary symbols. These symbols are transmitted over erroneous channels to FC and are proceeded by a training symbol, to facilitate channel estimation. We derive the optimal fusion rules, given the channel estimates. We show for binary PSK modulation error probability is minimized when each sensor allocates its power equally between training and data. For binary FSK error is minimized when power is allotted to data symbols only.

Track G – Architecture and Implementation

Session: WAa7 – Implementation of Wireless Systems

Chair: ***Roger Woods,*** *Queens University*

WA7a-1 8:15 AM

Field-Order Based Hardware Cost Analysis of Non-Binary LDPC Decoders

Yuta Toriyama, Behzad Amiri, Lara Dolecek, Dejan Markovic, University of California, Los Angeles, United States

Non-binary low-density parity-check codes exhibit excellent coding gain at the cost of high decoding complexity. Furthermore, while increasing the Galois field order improves the error rate, its effects on the hardware implementation cost have not been established. We propose a modification to the Min-Max algorithm to simplify calculations while maintaining decoding performance. In addition, a hardware area efficiency analysis is proposed, allowing a quantified exploration of the decoder design space. This hardware estimation model is utilized to reveal 1dB coding gain or 2x implementation efficiency gain of the proposed algorithmic simplifications, relative to the original algorithm.

WA7a-2 8:40 AM

Algorithm and Architecture for Hybrid Decoding of Polar Codes

Bo Yuan, Keshab K. Parhi, University of Minnesota, Twin Cities, United States

Polar codes are the first provable capacity-achieving forward error correction (FEC) codes. However, their error-correcting performance under successive cancellation (SC) or belief propagation (BP) decoding algorithm is limited and need to be improved. In this work, we propose a BP-SC hybrid decoding scheme to improve performance of polar codes. Simulation results show that for (1024, 512) polar codes the proposed approach can lead to 0.2dB coding gain over SC or BP algorithm. In addition, we also propose the low-complexity hardware architecture of the hybrid polar decoder.

WA7a-3 9:05 AM

A Signal Processing Approach Towards Ultra-Low Power Transceiver Design

Vijay Venkateswaran, Pawel Rulikowski, Howard Huang, Bell Labs, Ireland

This work explores the design of ultra-low power transceivers from a signal processing approach. We propose an ultra-low power wake-up radio based on super-regenerative receiver, which is always turned on and is used to detect the beacon signal coming from the access network, and to subsequently enable the rest of the transceiver. However, such low-power radios suffer from poor sensitivity.The objective of this paper is to use efficient signal shaping techniques used in combination with ultra-low power receivers in order to achieve significant power savings as well as improving its receiver sensitivity.

WA7a-4 9:30 AM

A High Performance GPU-based Software-defined Basestation

Kaipeng Li, Michael Wu, Guohui Wang, Joseph R. Cavallaro, Rice University, United States

In this paper, we present the implementation of a real-time software-defined radio(SDR) system based on graphics processing unit(GPU) and WARP radio platform.Both sides of the transceiver consist of two components: a software component running on general purpose processor for baseband processing, and a hardware component running on WARP FPGA for radio configuration and signal transmission.Our major work is focused on improving the capability of the bridge module between software and hardware components and fully utilizing computational resources on GPU for accelerating baseband processing algorithms.Our final target is to explore the implementation of a high performance OFDM SDR system on GPU.

Session: WAb7 – Video Coding Architecture and Design

Chair: ***Jorn Janneck,*** *Lund University*

WA7b-1 10:15 AM

Development and Optimization of High Level Dataflow Programs: the HEVC Decoder Design Case

Khaled Jerbi, INSA of Rennes / IETR, France; Daniele Renzi, Damien De Saint-Jorre, École Polytechnique Fédérale de Lausanne, Switzerland; Hervé Yviquel, INSA of Rennes / IETR, France; Claudio Alberti, École Polytechnique Fédérale de Lausanne, Switzerland; Mickaël Raulet, INSA of Rennes / IETR, France; Marco Mattavelli, École Polytechnique Fédérale de Lausanne, Switzerland

The availability of high resolution screens supporting 4K and 8K Ultra High Definition TV formats, has raised the requirements for better performing video compression algorithms. With this objective MPEG has recently finalized the development of the new High Efficiency Video Coding (HEVC) video compression standard successfully addressing these demands in terms of higher compression and increased potential parallelism when compared to previous standards. So as to guarantee real-time processing for such extremely high data rates, exploiting the parallel capabilities of recent many/multi-core processing platforms is in most of the cases an obliged implementation option for both encoders and decoders. In this context dataflow programming is a particularly attractive approach because its intrinsic properties provides the portability of the potential parallelism on different processing platform. The MPEG-RVC framework is an ISO/IEC standard conceived to address these needs. It is essentially constituted by the RVC-CAL actor dataflow language and a network language, and aims at replacing the traditional monolithic standard specification of video codecs with a dataflow specification that better satisfies the implementation challenges. The library of actors is written in RVC-CAL and provides the components that are configured using the network language to build a dataflow program implementing an MPEG decoder. This work describes the current development and optimization of the dataflow RVC library of the HEVC standard decoder. The RVC dataflow specification of a HEVC standard decoder is composed by four main part: the "parser", the "residual", the "prediction"and the "filter". Moreover, the current specification is conformant with most of the JCT-VC conformance streams. However, the first implementations have revealed poor performance if compared to the optimized sequential specifications and implementations such as the standard MPEG HEVC Model HM and an open source implementation called OpenHEVC. This work describes the analysis methodology, the transformations, the generic and platform specific optimizations applied to the initial fully working HEVC dataflow program. It reports the performance increases achieved for both single core and many/multi-core platforms resulting from the implementations synthesized from the high level dataflow program and applying different configuration (i.e. parallelization) options. Beside the possibility of using different dataflow network structures, the standard RVC dataflow program may also be instantiated by including platform-specific optimizations. In particular, the paper presents the results of applying Intel SSE kernels to accelerate the actors sequential processing (i.e. actions) and of providing cache-efficient FIFO channels implementations that speed-up the data communication between processor cores. These optimizations yielded an average gain of 400% in performance compared to the implementation not using SSE extensions of the standard specification. All described refactoring and optimizations generate a dataflow program implementation that decode HDTV resolution streams beyond real-time on standard PC platforms.

WA7b-2 10:40 AM

A Low-Power Hybrid Video Recording System with H.264/AVC and Light-Weight Compression

Hyun Kim, Seoul National University, Republic of Korea; Chae Eun Rhee, Inha University, Republic of Korea; Hyuk-Jae Lee, Seoul National University, Republic of Korea

To reduce the power consumption of mobile video recording systems is important to extend the lifetime of the battery. This paper proposes a low-power video recording system that combines both H.264/AVC with high compression efficiency and light-weight compression (LWC) with low power consumption. LWC compresses video data temporarily. When the temporal data are determined to be meaningful, they are compressed through H.264/AVC to be stored permanently. For further power reduction, down-sampling method is utilized for the permanent storage. The proposed video recording system achieves a power reduction of 74.4% compared to the conventional video recording system which uses only H.264/AVC.

WA7b-3 11:05 AM

Design of View Synthesis Prediction in 3D-HEVC via Algorithmic Complexity Analysis

Gwo Giun (Chris) Lee, Bo-Syun Li, Chun-Fu Chen, National Cheng Kung University, Taiwan

This paper presents a systematical approach to evaluate a system from both perspectives of algorithmic performance and complexity. The complexity metrics in this paper have the merits that are transparent to either algorithm or architecture. A case study of coding tool, backward view synthesis prediction in 3D-HEVC, is provided to demonstrate the evidence of the proposed

approach. Consequently, in comparison to HTM-7.0r1, the experimental result did not reduce the coding performance on average and the complexity of proposed method shows that the data transfer rate and the number of storage accessing could be reduced up to 28.85% and 93.63%, respectively.

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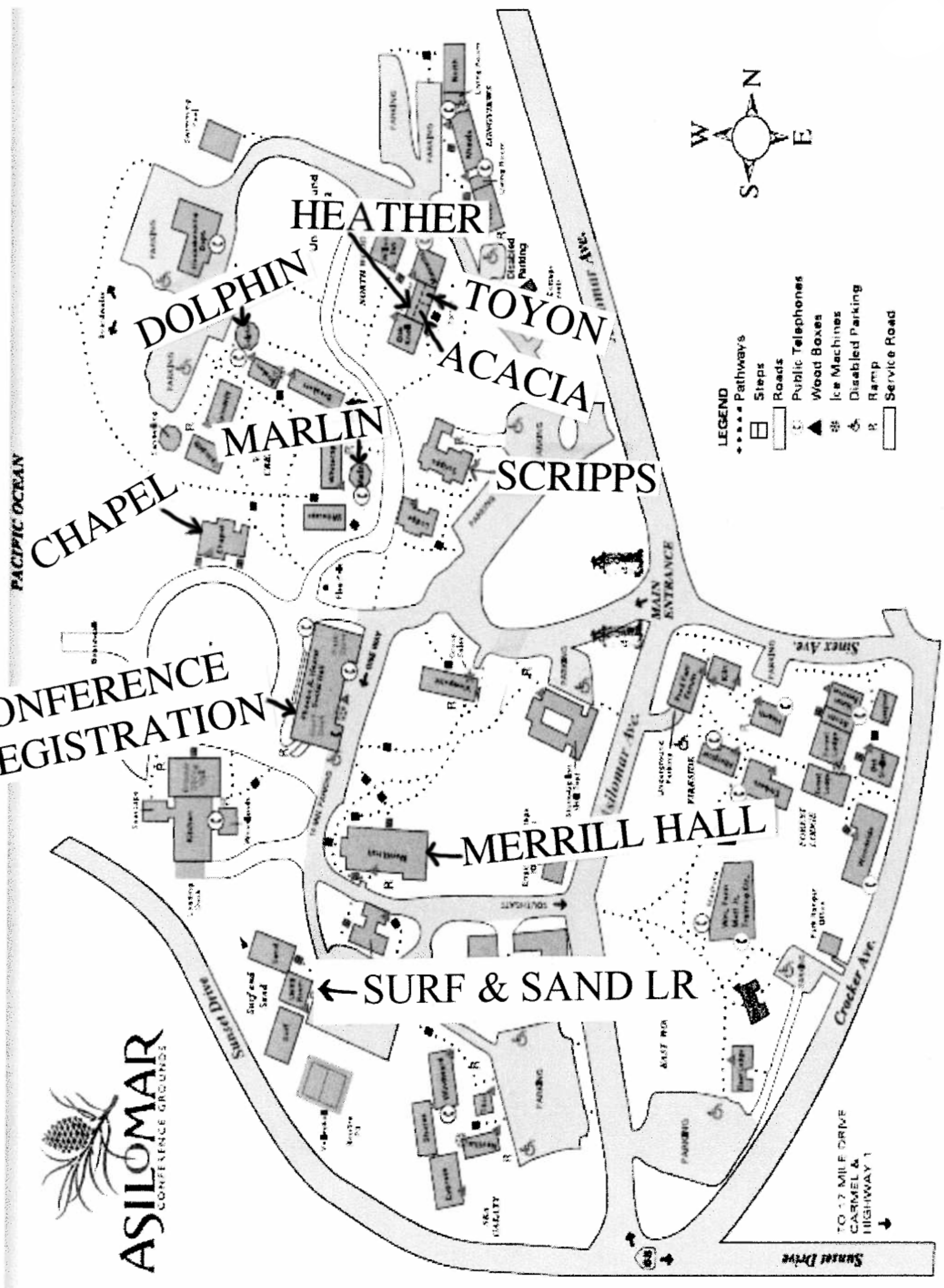
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