IEEE Sensor Array and Multichannel Signal Processing 2010

SAM 2010

October 4-7, 2010, ISRAEL

Technical Program

Monday, October 4

12:00 *Registration*

14:00 *Opening remarks*

14:15 *Plenary 1: An Information Theoretic View of Robust Cooperation/Relaying in Wireless Networks*

15:15 *Coffee break*

15:30 *Poster session I*

18:00 *Plenary 2: Parallel Magnetic Resonance Imaging: a Multi-Channel Signal Processing Perspective*

19:30 *Welcome Reception*

Tuesday, October 5

08:30 *Plenary 3: A Data Processing Pipeline for the Cosmic Microwave Background*

09:30 *MIMO Radar*
Underwater acoustic communications I

10:30 *Coffee break*

11:00 *Underwater acoustic communications II*
Performance bounds I

12:00 *Lunch*

13:30 *Plenary 4: Calibration Challenges for Large Radio Telescope Arrays*

14:30 *Performance bounds II*

15:50 *Coffee break*

16:00 *Poster session II*

19:30 *Jerusalem tour*

Wednesday, October 6

08:30 *Plenary 5: Performance-Driven Information Fusion*

09:30 *High dimensional covariance estimation*
Low rank matrix approximation

10:45 *Coffee break*

11:00 *Multichannel DSL*

12:00 *Lunch*

13:30 *Poster session III*

15:30 *Plenary 6: Direct Position Determination and Sparsity in Localization Problems*

19:30 *Banquet + Jaffa tour (transportation to Tel-Aviv at 16:45)*

Thursday, October 7

8:00 *Hi-Tech Industry Visit*

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Monday, October 4

12:00 - 14:00

Registration

14:00 - 14:15

Opening remarks: Hagit Messer-Yaron

14:15 - 15:15

Plenary 1: An Information Theoretic View of Robust Cooperation/ Relaying in Wireless Networks

Shlomo Shamai, Technion-Israel Institute of Technology, Israel
Abstract: In many wireless networks, cooperation, in the form of relaying, takes place over out-of- band spectral resources. Examples are ad hoc networks in which multiple radio interfaces are available for communications or cellular systems with (wireless or wired) backhaul links. In an overview from an information-theoretic standpoint, we put emphasis on robust processing and cooperation via out-of-band links for both ad hoc and cellular networks. Specifically, we focus on robust approaches and practical aspects such as imperfect information regarding the channel state and the codebooks (modulation, coding) shared by transmitters and receivers. First, we address cooperation scenarios with perfect channel state information and investigate the impact of lack of information regarding the codebooks (oblivious processing) on basic relay channels and cellular systems with cooperation among base stations. Then, similar models are examined in the absence of perfect channel state information. Robust coding strategies are designed based on 'variable-to-fixed' channel coding concepts (the broadcast coding approach, or unequal error protection codes). The effectiveness of such strategies are discussed for multirelay channels and cellular systems overlaid with femtocell hotspots.

15:15 - 15:30

Coffee break

15:30 - 18:00

Poster Session I - Student Competition Papers

Session Chair: Arie Yeredor (Tel-Aviv University, Israel)

Robust Focusing for Wideband MVDR Beamforming

Yaakov Buchris (Technion, Israel institute of technology, Israel); Israel Cohen (Technion - Israel Institue of Technology, Israel); Miriam Doron (RAFAEL, Advanced Defense Systems LTD, Israel)

Abstract: In this paper, we propose and study two robust methods for coherent focused wideband Minimum Variance Distortionless Response (MVDR) beamforming. The focusing procedure introduces a frequency dependent focusing error which causes performance degradation, especially at high Signal to Noise Ratio (SNR) values. The proposed robust methods aim at reducing the sensitivity of the coherent MVDR to focusing errors. The first method is based on modifying the beamformer optimization problem and generalizing it to bring into account the focusing transformations and the second is based on modifying the focusing scheme itself. A numerical study demonstrates a significant performance improvement of the proposed robust schemes when applied, using the Wavefield Interpolated Narrowband Generated Subspace (WINGS) focusing transformation.

Estimating the Performance of a Superdirective Microphone Array with a Frequency-Invariant Response

Federico Traverso (University of Genoa, Italy); Marco Crocco (University of Genoa, Italy); Andrea Trucco (University of Genoa, Italy)

Abstract: The knowledge of the impact of sensors tolerances in the beamformer performance is of crucial importance in many design cases, especially when superdirective arrays are employed. The availability of the array characteristics (i.e. perturbations on sensors responses and elements displacement), allows to obtain an expectation of the system capabilities corrupted by realistic imperfections. In this paper we discuss the effectiveness of the expected beam pattern as an a priori criterion for the beamformer performance estimation. In particular, the expected beam power pattern has been compared to the actual one, resulted from an experimental investigation of a superdirective microphone array. The tight adherence between the two beam shapes accounts for the effectiveness of the proposed tool in driving the system design.

Multiantenna Spectrum Sensing: The Case of Wideband Rank-One Primary Signals

David Ramírez (University of Cantabria, Spain); Javier Via (University of Cantabria, Spain); Ignacio Santamaria (University of Cantabria, Spain)

Abstract: One of the key problems in cognitive radio (CR) is the detection of primary activity in order to determine which parts of the spectrum are available for opportunistic access. In this work, we present a new multiantenna detector which fully exploits the spatial and temporal structure of the signals. In particular, we derive the generalized likelihood ratio test (GLRT) for the problem of detecting a wideband rank-one signal under spatially uncorrelated noise with equal or different power spectral densities. In order to simplify the maximum likelihood (ML) estimation of the unknown parameters, we use the asymptotic likelihood in the frequency domain. Interestingly, for noises with different distributions and under a low SNR approximation, the GLRT is obtained as a function of the largest eigenvalue of the spectral coherence matrix. Finally, the performance of the proposed detectors is evaluated by means of numerical simulations, showing important advantages over previously proposed approaches.

Blind Extraction Algorithm With Direct Desired Signal Selection

Brian Bloemendal (Eindhoven University of Technology, The Netherlands); Jakob van de Laar (Philips Research Laboratories, The Netherlands); Piet Sommen (Eindhoven University of Technology, The Netherlands)

Abstract: In many practical applications we are interested in the extraction of only one, desired signal out of a mixture of signals. A disadvantage of most blind extraction approaches proposed in the literature is that they are inefficient in the sense that they also separate or extract undesired signals. To deal with this inefficiency we exploit an a priori guess of direction of arrival related parameters of the desired signal, which serves as a mold. Based on this mold we create linear combinations of noise-free correlation matrices that are used to construct a single matrix with a specific eigenstructure. The eigenvector that corresponds to the smallest eigenvalue of this matrix is the desired extraction filter. Finally it is shown that this approach paves the way to make the algorithm flexible in the utilization of additional a priori information.

Likelihood-Ratio and Channel Based Access for Energy-Efficient Detection in Wireless Sensor Networks

Kobi Cohen (Bar-Ilan university, Ramat-Gan, 52900, Israel); Amir Leshem (Bar-Ilan University, Israel)

Abstract: We examine transmission scheduling by medium access control (MAC) for energy-efficient detection using Wireless Sensor Networks (WSN). We focus on the binary hypothesis testing problem. The decision is made by an access point and based on received data from sensors that transmit through a fading channel. We study the significance of exploiting both Channel-State Information (CSI) and Likelihood-Ratio Information (LRI) to design adequate MAC protocol that minimizes the total transmission energy required for the detection problem. By formulating the problem as a Stochastic Shortest Path (SSP) problem we design the LRI and CSI Based Access (LCBA) protocol. LCBA trades off between LRI and CSI to minimize the total transmission energy. It allows sensors to access the channel according to the optimal policy which solves the formulated SSP problem.

Subspace-Based Direction-of-Arrival Estimation for More Sources Than Sensors Using *Planar Arrays*

Michael Rübsamen (Darmstadt University of Technology, Germany); Alex Gershman (Darmstadt University of Technology, Germany)

Abstract: We propose a novel subspace-based direction-of-arrival (DOA) estimation method and an associated planar array geometry optimization technique. The proposed DOA estimation approach allows to estimate the DOAs of more sources than sensors and to resolve manifold ambiguities in the case of uncorrelated signals. It is related to the covariance augmentation (CA) technique, but in contrast to the CA technique, it can be applied to non-uniform planar array geometries.

Optimal Subsampling of Multichannel Damped Sinusoids

Gilles Chardon (UPMC Univ Paris 06, France); Laurent Daudet (Université Paris Diderot, France)

Abstract: In this paper, we investigate the optimal ways to sample multichannel impulse responses, composed of a small number of exponentially damped sinusoids, under the constraint that the total number of samples is fixed - for instance with limited storage / computational power. We compute Cramer-Rao bounds for multichannel estimation of the parameters of a damped sinusoid. These bounds provide the length during which the signals should be measured to get the best results, roughly at 2 times the typical decay time of the sinusoid. Due to bandwidth constraints, the signals are best sampled irregularly, and variants of Matching Pursuit and MUSIC adapted to the irregular sampling and multichannel data are compared to the Cramer-Rao bounds. In practical situation, this method leads to savings in terms of memory, data throughput and computational complexity.

UWB Localization via Multipath Distortion

Moshe Uziel (The Hebrew University, Israel); Dana Porrat (The Hebrew University, Israel)

Abstract: A new method for non line of sight transmitter localization is suggested, based on the effective bandwidth of different multipath components in the UWB channel response. The method essentially relies on the difference in the distortion applied by the channel to early and to late arrivals in the channel impulse response, the early arrivals have a wider effective bandwidth. Localization results on measured channel responses show the superiority of the new method over a method based on a multipath energy detector.

Space-time Compressive Sampling Array

Ying Wang (Philips Research, Eindhoven, The Netherlands); Geert Leus (Delft University of Technology, The Netherlands)

Abstract: We propose a space-time compressive sampling (STCS) array architecture by exploiting the sparsity in the angle and frequency domain. Two Doppler-DoA estimation methods are designed to efficiently reconstruct the two-dimensional (2D) sparse signal. The STCS array together with the 2D reconstruction methods allow for accurate yet low-power location and speed estimation of moving targets. The proposed methods are not only tested by

simulations but also using an experimental setup consisting of an ultrasonic sensor array.

3D Electromagnetic Imaging Using Compressive Sensing

Marija Stevanovic (Washington University in Saint Louis, USA); Gongguo Tang (Washington University in St. Louis, USA); Arye Nehorai (Washington University in St. Louis, USA)

Abstract: We develop the application of compressive sensing (CS) for solving general inverse electromagnetic problems such as three-dimensional (3D) microwave imaging. The goal is to estimate locations of unknown, but sparse targets, hidden inside dielectric bodies. The potential of CS for localizing sparse targets in vacuum or buried in ground was shown in previous work. We extend the proposed schemes by considering arbitrary embedding medium and exploiting dual-polarized measurements. We compare the performance of CS and beamforming in the breast-cancer estimation problem.

Modeling Neuron Firing Pattern Using a Two State Markov Chain

Nir Nossenson (Tel Aviv University, Israel); Hagit Messer (Tel-Aviv University, Israel)

Abstract: We study a possible model for neuron firing pattern as a two state Markov chain. We compare the qualitative predications of the model with various types of neural measurements available in the literature. It is shown that this model explains well several phenomena observed in different sensory systems of mammals.

Consensus for Distributed EM-Based Clustering in WSNs

Silvana Silva Pereira (Universitat Politècnica de Catalunya - Barcelona Tech, Spain); Sergio Barbarossa (University of Rome, Italy); Alba Pagès-Zamora (Technical University of Catalonia, Spain)

Abstract: A distributed EM algorithm with consensus is proposed for density estimation and clustering in the presence of mixtures of Gaussians using WSNs. The EM algorithm is a general framework for maximum likelihood estimation in hidden variable models, and is usually implemented in a central node with global information of the network. The average consensus algorithm is a simple but robust scheme for computing averages in a distributed manner. In this contribution, we run a distributed EM algorithm where the nodes obtain global knowledge of the statistics through consensus with local information exchange only. Starting from a set of initial values, the nodes are able to compute the complete statistics of a mixture of Gaussians and form clusters according to the sensed density using a simple decision rule. A trade off between power consumption and final accuracy of the estimates is established through simulations.

A Rayleigh Fading Interference Game with Iincomplete Information

Yair Noam (Tel Aviv University., 69978 Israel); Amir Leshem (Bar-Ilan University, Israel); Hagit Messer (Tel-Aviv University, Israel)

Abstract: In this paper we study the interaction between two wireless communication systems in interference Rayleigh fading channel with incomplete information where players choose between frequency division multiplexing (FDM) and full spread (FS) of their transmit power. Previously, a FDM equilibrium point was derived and was shown to be pareto dominant (i.e. component wise larger payoff) over the pure-FS NE point in which both players use the entire band and interfere with each other. This quality makes the FDM equilibrium a desirable operating point to which distributed algorithms for spectrum management may converge to. In this paper, we show that the previously derived FDM equilibrium point exists and is unique in Rayleigh fading channels. This is important for its future implementation. We conclude with a study the effect of the averaged received power on the behaviour of selfish users in such channels.

Optimal Bayesian Parameter Estimation with Periodic Criteria

Tirza Routtenberg (Ben Gurion University of the Negev, Israel); Joseph Tabrikian (Ben-Gurion University of the Negev, Israel)

Abstract: In this paper, a new method for Bayesian periodic parameter estimation is derived using periodic cost functions. The estimation procedure is evaluated using Fourier series representation of the periodic cost functions. The minimum cyclic and the minimum periodic mean-square-error (MSE) estimators are derived. The proposed periodic estimators are applied to frequency estimation and direction-of-arrival (DOA) estimation problems and their performance are compared with the minimum mean-square-error (MMSE) and maximum a-posteriori probability (MAP) estimators in terms of periodic MSE (PMSE).

18:00 - 19:00

Plenary 2: Parallel Magnetic Resonance Imaging: a Multi-Channel Signal Processing Perspective

Yoram Bresler, University of Illinois, Urbana-Champaign, USA

Abstract: Magnetic resonance imaging (MRI) is one of the leading diagnostic imaging modalities. While providing excellent spatial resolution and exquisite soft tissue contrast, MRI suffers from slow acquisition. One of the highly effective approaches developed to address this limitation, is parallel imaging with phased-array coils. However, the freedom in acquisition, modeling, coil calibration, and reconstruction is often dealt with in a heuristic way. In this talk we provide a signal processing perspective on these problems, emphasizing the multichannel structure. We show that this perspective provides some interesting variations with improved performance

19:30 - 21:00

Welcome Reception

Tuesday, October 5

08:30 - 09:30

Plenary 3: A Data Processing Pipeline for the Cosmic Microwave Background

Jean-Francois Cardoso, LTCI, TELECOM Paris, France

Abstract: At the Sun-Earth Lagrange point L2, 1.5e6 km away from Earth, an array of 63 sensors aboard the Planck satellite is scanning the sky, patiently measuring to unprecedented resolution and sensitivity the micro-Kelvin fluctuations of the Cosmic Microwave Background temperature and polarization. Getting from there to building multi-million-pixel spherical maps of the microwave sky in 9 frequency channels, to reconstructing the history of our Universe is a story in technology, cosmology and... challenging signal processing. This talk will highlight some of the key steps of the data processing pipeline being developed for the Planck space mission of ESA.

09:30 - 10:30

MIMO Radar

Session Chair: Jeffrey L. Krolik (Duke University, USA)

9:30 Estimating the Parameters of a Moving Target in MIMO Radar with Widely Separated Antennas

Abdulnasr Hassanein (University of Alberta, Canada); Sergiy A. Vorobyov (University of Alberta, Canada); Alex Gershman (Darmstadt University of Technology, Germany); Michael Rübsamen (Darmstadt University of Technology, Germany)

Abstract: In this paper, we develop a new maximum likelihood (ML) moving target parameter estimation technique for multiple-input multiple-output (MIMO) radar. It is required for this technique that different receive antennas have the same time reference, but no synchronization of initial phases of the receive antennas is needed and, therefore, the estimation process is non-coherent. The target motion within a certain processing interval is modeled as a second-order polynomial whose coefficients are given by the initial location, velocity, and acceleration of the target. The proposed ML estimator is able to jointly process the data collected from multiple consecutive radar pulses. It is shown that the considered ML problem simplifies to the classic "overdetermined" nonlinear least-squares problem. The proposed ML estimator requires multi-dimensional search over the unknown location, velocity, and acceleration parameters. The performance of the proposed estimator is validated by simulation results.

9:45 Waveform Design for Sequential MIMO Detection

Emanuele Grossi (University of Cassino, Italy); Marco Lops (University of Cassino, Italy)

Abstract: In this paper, a sequential multiple-input multiple-output detection problem is considered. Minimization of the the weighted average of the Kullback-Leibler divergences between the densities of the observations under the two hypotheses (which permits to control the average sample number under the two hypotheses) is pursued when the transmitted energy budget is limited. Closed form expression of the structure of the optimum code matrix is found, and a simple numerical algorithm to find the optimal power allocation is given.

10:00 MIMO GMTI Radar with Multipath Clutter Suppression

Jeffrey Krolik (Duke University, USA); Granger Hickman (Duke University, USA)

Abstract: This paper address ground-moving target indicator (GMTI) radar operation in the presence of strong multipath spread-Doppler clutter (SDC). Space-time adaptive processing (STAP) for single-input-single-output (SIMO) radar is designed to mitigate direct-path SDC which leaks into the sidelobes of a moving radar platform. However, multipath SDC often returns via the receiver mainlobe and cannot be suppressed in a SIMO radar without also canceling the target. In this paper, we study multipath SDC mitigation using multiple-input-multiple-output (MIMO) GMTI radar. Clutter loci and adaptive array patterns for MIMO GMTI are presented in multipath SDC. By achieving range-dependent nulling on transmit, the effectiveness of MIMO GMTI radar at suppressing multipath SDC is shown.

10:15 Fundamental Limitations of Pixel Based Image Deconvolution in Radio Astronomy

Sarod Yatawatta (Kapteyn Institute/ASTRON, The Netherlands)

Abstract: Deconvolution is essential for radio interferometric imaging to produce scientific quality data because of finite sampling in the Fourier plane. Most deconvolution algorithms are based on CLEAN which uses a grid of image pixels, or clean components. A critical matter in this process is the selection of pixel size for optimal results in deconvolution. As a rule of thumb, the pixel size is chosen smaller than the resolution dictated by the interferometer. For images consisting of unresolved (or point like) sources, this approach yields optimal results. However, for sources that are not point like, in particular for partially resolved sources, the selection of right pixel size is still an open issue. In this paper, we investigate the limitations of pixelization in deconvolving extended sources. In particular, we pursue the usage of orthonormal basis functions to model extended sources yielding better results than by using clean components.

Underwater Acoustic Communications I

Session Chair: Andrew C. Singer (University of Illinois at Urbana Champaign, USA)

9:30 Efficient Channel Equalization for MIMO Underwater Acoustic Communications

Ling Jun (University of Florida, USA); Xing Tan (University of Florida, USA); Jian Li (University of Florida, USA); Magnus Lundberg Nordenvaad (Luleå University of Technology, Sweden)

Abstract: Linear minimum mean-squared error (LMMSE)- based channel equalization is widely used in multi-input multioutput (MIMO) underwater acoustic communications (UAC). The practical challenge of LMMSE based schemes is the necessity of matrix inversion which generally imposes heavy computational burden on the receiver. To obtain the LMMSE filters efficiently, we exploit the conjugate gradient method and the diagonalization properties of circulant matrices. The proposed scheme is based on fast Fourier transform operations and can be implemented in parallel, which makes it a promising candidate for real-time MIMO underwater acoustic communications. Both numerical and SPACE'08 experimental examples are presented to demonstrate the effectiveness of the proposed approach.

9:50 Adaptive Linear Turbo Equalization of Large Delay Spread Time-Varying Channel Responses

Jun Won Choi (University of Illinois at Urbana-Champaign, USA); Thomas Riedl (University of Illinois at Urbana Champaign, USA); Erica L Daly (University of Illinois at Urbana Champaign, USA); Kyeongyeon Kim (University of Illinois at Urbana-Champaign, USA); Andrew C. Singer (University of Illinois at Urbana Champaign, USA); James Preisig (Woods Hole Oceanographic Institution, USA)

Abstract: In this paper, we investigate applying linear turbo equalization techniques to underwater acoustic communications. First, we elaborate on two popular linear turbo equalizers, a channel estimate-based minimum mean square error TEQ (CE-based MMSE-TEQ) and a direct-adaptive TEQ (DA-TEQ). We compare the behavior of both TEQ approaches in the presence of channel estimation errors and adaptation filter adjustment errors. By analyzing extrinsic information transfer (EXIT) charts, we confirm that the performance gap between these two TEQs is small after convergence. Next, we introduce an underwater receiver architecture based on the LMS DATEQ technique that dramatically improves the performance of the conventional decision-feedback equalizer at a feasible complexity. This receiver architecture is demonstrated using data collected from the SPACE 08 experiment. The experimental results demonstrate that the LMS DA-TEQ yields more than an order of magnitude performance gain over the conventional equalizer.

10:10 Joint Channel Estimation and Markov Chain Monte Carlo Detection for Frequency-Selective Channels

Hong Wan (Unviersity of Utah, USA); Rong-Rong Chen (University of Utah, USA); Jun Won Choi (University of Illinois at Urbana-Champaign, USA); Andrew C. Singer (University of Illinois at Urbana Champaign, USA); James Preisig (Woods Hole Oceanographic Institution, USA); Behrouz Farhang-Boroujeny (Univ of Utah, USA)

Abstract: In this paper, we develop a novel approach for joint channel estimation and Markov Chain Monte Carlo (MCMC) detection for time-varying frequency-selective channels. First, we propose a sequential channel estimation (SCE) MCMC algorithm that combines an MCMC algorithm for data detection, and an adaptive least mean square (LMS) algorithm for channel tracking, in a sequential fashion. Then we develop a stochastic expectation maximization (SEM) MCMC algorithm that takes advantage of both the MCMC approach and the EM algorithm to find jointly important samples of the transmitted data and channel impulse response (CIR). The proposed algorithms provide a low-complexity means to approximate the optimal maximum a posterior (MAP) detection in a statistical fashion and are applicable to channels with long memory. Excellent behavior of the proposed algorithms is presented using both synthetic channels and real data collected from actual underwater acoustic experiments.

10:30 - 11:00

Coffee break

11:00 - 12:00

Underwater Acoustic Communications II

Session Chair: James Preisig (Woods Hole Oceanographic Institution, USA)

11:00 A Method for Differentially Coherent Detection of OFDM Signals on Doppler-Distorted Channels

Milica Stojanovic (Northeastern University, USA)

Abstract: Doppler distortion causes inter-carrier interference which prevents the use of differentially coherent detection in OFDM systems. To recover this efficient detection method, we propose to use several FFT demodulators operating in parallel over non-overlapping time segments, and to combine their outputs prior to detection. This technique aims for efficient implementation of front-end matched filtering, followed by differential MMSE combining. A low complexity algorithm is proposed for recursive computation of combiner weights, and its gain over the conventional detector is quantified through numerical examples of an underwater acoustic channel with severe Doppler distortion.

11:20 Isotropic Filter Design for MIMO Filter Bank Multicarrier Communications

Pooyan Amini (University of Utah, USA); Chung Him (George) Yuen (University of Utah, USA); Rong-Rong Chen (University of Utah, USA); Behrouz Farhang-Boroujeny (Univ of Utah, USA)

Abstract: Although orthogonal frequency division multiplexing (OFDM) has been the dominant technology for broadband communications in the past, a number of researchers have noted the shortcomings of OFDM in fast-fading time-varying channels, e.g., underwater acoustic channels. Hence, alternative systems that use filter banks for multicarrier modulation have been proposed. The widely studied filter bank multicarrier (FBMC) systems use offset quadrature amplitude modulation (OQAM) or cosine modulated filter bank (CMFB) to maximize the transmission efficiency by maximizing the number of subcarriers in the available band. Moreover, the use of isotropic pulses for prototype filters will allow one to strike a balance between the time and frequency dispersion of the channel.

11:40 Reduced Bandwidth Frequency Domain Equalization for Underwater Acoustic Communications

James Preisig (Woods Hole Oceanographic Institution, USA); Andrew C. Singer (University of Illinois at Urbana Champaign, USA); Gregory Wornell (Massachusetts Institute of Technology, USA)

Abstract: Two challenges facing adaptive decision feedback equalizers (DFEs) in the underwater acoustic channel are those of the channel changing too rapidly to allow for the stable adaptation of the number of coefficients required to represent the equalizer filters and the high computational complexity of the associated adaptation algorithms. These challenges are particularly acute for multichannel DFEs where a separate filter needs to be adapted for each input signal channel. A multichannel "frequency domain" DFE is proposed in which the feedforward filter coefficients are represented in the frequency domain while the feedback filter coefficients are represented in the time domain. For fractionally sampled input signals, the frequency range over which the feedforward filter coefficients are calculated is limited thus reducing the number of coefficients that need to be calculated. The resulting DFE is shown to have both improved demodulation performance and a reduced complexity when compared to a time domain equalizer.

Performance Bounds I

Session Chair: Joseph Tabrikian (Ben-Gurion University of the Negev, Israel)

11:00 Performance Bounds for the Estimation of Finite Rate of Innovation Signals from Noisy Measurements

Zvika Ben-Haim (Technion - Israel Institute of Technology, Israel); Tomer Michaeli (Technion - Israel Institute of Technology, Israel); Yonina C. Eldar (Technion---Israel Institute of Technology, Israel)

Abstract: In this paper, we derive lower bounds on the estimation error of finite rate of innovation signals from noisy measurements. We first obtain a

fundamental limit on the estimation accuracy attainable regardless of the sampling technique. Next, we provide a bound on the performance achievable using any specific sampling method. Essential differences between the noisy and noise-free cases arise from this analysis. In particular, we identify settings in which noise-free recovery techniques deteriorate substantially under slight noise levels, thus quantifying the numerical instability inherent in such methods. The results are illustrated in a time-delay estimation scenario.

11:15 Numerically Efficient Mean Squared Error Threshold SNR Prediction for Adaptive Arrays

Christ D. Richmond (MIT Lincoln Laboratory, USA)

Abstract: The method interval estimation (MIE) is an established technique for extending asymptotic mean squared error (MSE) predictions like the Cramer-Rao bound to lower signal-to-noise ratios. While application of MIE to the adaptive array problem was successful in [1], the numerical integration required to compute the pairwise error probabilities central to MIE is computationally expensive. This is primarily due to the double integral required, moreover, the integrand itself involves the Marcum Q-function, a specialize function that can be represented as an integral or infinite series. System analysis and design often requires computing MSE performance over a wide search space that easily demands hundreds to tens of thousands of repeated calculations of the pairwise error probabilities. To support this demand two approaches to approximating the required error probabilities are explored herein, one yielding a near ~235 times speedup factor in computation without major loss in accuracy of MSE prediction.

11:30 Outage Error Probability Lower Bounds in Vector Parameter Estimation

Tirza Routtenberg (Ben Gurion university of the Negev, Israel); Joseph Tabrikian (Ben-Gurion University of the Negev, Israel)

Abstract: In this paper, a new class of lower bounds on the outage error probability in Bayesian vector parameter estimation is proposed. The minima of the *h*-outage error probability is obtained by the generalized maximum a-posteriori probability. However, computation of this estimator and its corresponding performance is usually not tractable and thus, lower bounds on the outage error probability can be very useful for performance analysis. The proposed class of lower bounds on the outage error probability is derived using Holder's inequality. The proposed bounds were implemented for the linear Gaussian model. It was shown that in this case the tightest proposed bound attained the minimum probability of outage error.

11:45 Information Theoretic Bounds on Mobile Source Localization in a Dense Urban Environment

Igal Bilik (University of Massachusetts, USA); Kaushallya Adhikari (University of Massachusetts Dartmouth, USA); John Buck (University of Massachusetts Dartmouth, USA)

Abstract: The FCC E-911 Phase-2 requirements have motivated increased interest in the challenge of localizing mobile sources in a dense urban environment. E-911 Phase-2 requires wireless carriers to provide the location of a 911 caller with accuracy of 100 meters in 67% of cases and 300 meters in 95% of cases. This paper proposes information theoretic bounds on source localization performance in a dense urban environment based on the distribution of received energy as a function of time and angle of arrival from the multipath propagation. The surveillance area is discretized into a grid of partitions where the partition size can be interpreted as a source localization accuracy. The proposed lower bound provides a limit on the achievable source localization accuracy for a given SNR. The bound is evaluated for several urban propagation scenarios.

12:00 - 13:30

Lunch

13:30 - 14:30

Plenary 4: Calibration Challenges for Large Radio Telescope Arrays

Alle-Jan van der Veen, TU Delft, The Netherlands

Abstract: Radio astronomy is known for its very large telescope dishes, but currently there is a transition towards the use of large numbers of small elements. E.g., the recently commissioned LOFAR low frequency array uses 50 stations each with some 200 antennas, and the numbers will be even larger for the Square Kilometer Array, planned for 2020. Meanwhile some of the existing telescope dishes are being retrofitted with focal plane arrays. These instruments pose interesting challenges for array signal processing. One aspect, which we cover in this talk, is the calibration of such large numbers of antennas, especially if they are distributed over a wide area. Apart from the unknown element gains and phases (which may be directionally dependent), there is the unknown propagation through the ionosphere, which at low frequencies may be diffractive and different over the extent of the array. The talk will discuss several of the challenges, present the underlying data models, and propose some of the answers. We will also touch upon a recent initiative to develop a low-frequency telescope array in space, on a distributed platform formed by a swarm of nanosatellites.

14:30 - 15:30

Performance Bounds II

Session Chair: Joseph Tabrikian (Ben-Gurion University of the Negev, Israel)

14:30 Constrained Hypothesis Testing and the Cramér-Rao Bound

Brian Sadler (Army Research Laboratory, USA); Terrence Moore (Army Research Laboratory, USA)

Abstract: The classical Wald and Rao test statistics are asymptotically equivalent to the generalized likelihood ratio test statistics, while not requiring parameter estimation under both hypotheses, and so they provide lower complexity test statistics. In this paper we develop corresponding variations of the Wald and Rao test for nested hypothesis testing under parameter constraints. The resulting tests incorporate the constrained Cramér-Rao bound formulation from Stoica and Ng, and unify some asymptotic hypothesis testing results. Examples will illustrate key ideas and test performance.

14:50 Achievable MSE Lower Bounds in Non-Bayesian Biased Estimation

Koby Todros (Ben Gurion University of the Negev, Israel); Joseph Tabrikian (Ben-Gurion University of the Negev, Israel)

Abstract: In this paper, a new structured approach for obtaining uniformly best biased (UBB) estimators, in the mean-square-error (MSE) sense, is established. We show that if a UBB estimator exists, then it is uniquely given by the locally best biased (LBB) estimator. A necessary and sufficient condition for the existence of a UBB estimator is derived, and it is shown that if there exists an optimal bias, such that this condition is satisfied, then it is unique, and the UBB estimator is directly obtained from the LBB estimator. The UBB estimator is derived in a non-linear Gaussian estimation problem. In comparison to the maximum-likelihood estimator, we show that the UBB estimator exhibits superior estimation performance in the MSE sense.

15:10 New Trends in Deterministic Lower Bounds and SNR Threshold Estimation

Eric Chaumette (ONERA, France)

Abstract: It is well known that in non-linear estimation problems the ML estimator exhibits a threshold effect, i.e. a rapid deterioration of estimation accuracy below a certain SNR or number of snapshots. This effect is caused by outliers and is not captured by standard tools such as the Cram´er-Rao bound (CRB). The search of the SNR threshold value can be achieved with the help of approximations of the Barankin bound (BB) proposed by many authors. These approximations may result from linear or non-linear transformation (discrete or integral) of the uniform unbiasness constraint introduced by Barankin. Additionnaly, the strong analogy between derivations of deterministic bounds and Bayesian bounds of the Weiss-Weinstein family has led us to propose a conjectural bound which outperforms existing ones for SNR threshold prediction.

15:30 Closed-Form Expression of the Weiss-Weinstein Bound for 3D Source Localization: the Conditional Case

Dinh Thang VU (University Paris Sud XI, France); Alexandre Renaux (Universite Paris 11, France); Rémy Boyer (CNRS, Université Paris-Sud (UPS), Supelec, France); Sylvie Marcos (Laboratoire des Signaux et Systems, Supélec, CNRS UMR8506, France)

Abstract: In array processing, lower bounds are used as a benchmark to evaluate the ultimate performance of estimators. Among these bounds, the Weiss-Weinstein bound (WWB) is known as the tightest bound of Weiss-Weinstein family, and is able to predict the threshold effect of estimator's mean square error (MSE) at low signal-to-noise ratio (SNR) and/or at low number of snapshots. In

this paper, we derive a closed-form expression of the WWB for 3D source localization using an arbitrary planar antenna array in the case of a deterministic known signal. The presented results are shown to be useful for system design such as array geometry optimization.

15:50 - 16:00

Coffee break

16:00 - 18:00

Poster Session II

Multichannel Blind Compressed Sensing

Sivan Gleichman (Technion, Israel Institute of Technology, Israel); Yonina C. Eldar (Technion---Israel Institute of Technology, Israel)

Abstract: Compressed sensing successfully recovers a signal, which is sparse under some basis representation, from a small number of linear measurements. However, prior knowledge of the sparsity basis is essential for the recovery process. The purpose of blind compressed sensing is to avoid the need for this prior knowledge. We consider blind compressed sensing in multichannel systems, in which the sparsity basis is unknown in both the sampling and recovery stages. Blind compressed sensing is achieved by simultaneously measuring several signals. We then suggest a simple algorithm to retrieve the unknown input. Under conditions presented in this work we demonstrate that our method can achieve results similar to those of standard compressed sensing, which rely on prior knowledge of the sparsity basis.

Sampling of Pulse Streams: Achieving the Rate of Innovation

Kfir Gedalyahu (Technion - Israel Institute of Technology, Israel); Ronen Tur (Technion- Israel Institute of Technology, Israel); Yonina C. Eldar (Technion---Israel Institute of Technology, Israel)

Abstract: We consider the problem of sampling signals which are comprised of pulse streams. This model belongs to the recently introduced framework of signals with finite rate of innovation. The minimal sampling rate for such signals is the number of degrees of freedom per unit of time, referred to as the rate of innovation. Although sampling of pulse streams was treated in various works, either the rate of innovation was not achieved, or the pulse shape was limited to diracs. In this work we propose multichannel schemes for arbitrary pulse streams, operating at the rate of innovation. The proposed approach is based modulating the input signal in each channel with a properly chosen waveform, followed by an integrator. We show that the pulses delays and amplitudes can be recovered from the samples using standard spectral estimation tools. The resulting scheme is flexible and exhibits better noise robustness than previous approaches.

Sparse Component Analysis for Linear Mixed Models

Martin Hurtado (National University of La Plata, Argentina); Nicolas von Ellenreider (National University of La Plata, Argentina); Carlos Muravchik (Universidad Nacional de La Plata, Argentina); Arye Nehorai (Washington University in St. Louis, USA)

Abstract: When seeking for a sparse solution of a linear model, a common technique is the search of a solution with minimum L1 norm. In this paper, we present a new approach for the case of sparse linear mixed models. We combine the expectation-maximization (EM) algorithm for solving the inverse problem with a decision test that guarantees sparseness by eliminating the statistically null components of the solution. We address its performance by means of simulations and illustrate its use with real radar data demonstrating its potential applications.

Band-Diagonal Regularization of Gaussian Interference Covariance Matrices ML Estimates

David Lekhovytskiy (Kharkov National University of Radio Electronics, Ukraine); Yuri Abramovich (Defence Science and Technology Organisation (DSTO), Australia); Oleksandr Dokhov (Kharkov National University of Radio Electronics, Ukraine); Valerii Zarytskyi (Kharkov National University of Radio Electronics, Ukraine); Gennadiy Zhuga (Kharkov National University of Radio Electronics, Ukraine); Dmytro Rachkov (Kharkov National University of Radio Electronics, Ukraine)

Abstract: The convergence rate of a number of adaptive processing algorithms for coherent signal extraction from Gaussian interference is compared. Our main attention is paid to a relatively new hybrid method of regularization of the maximum-likelihood estimate (MLE) of the covariance matrix (CM) of Gaussian vectors with discrete and continuous power spectra. Relatively high convergence rate and efficient lattice-filter-based implementation for the introduced technique are demonstrated.

Independent Component Analysis of Quaternion Gaussian Vectors

Javier Via (University of Cantabria, Spain); Luis Vielva (University of Cantabria, Spain); Ignacio Santamaria (University of Cantabria, Spain); Daniel P Palomar (Hong Kong University of Science and Technology, Hong Kong)

Abstract: This paper addresses the independent component analysis (ICA) of quaternion Gaussian vectors. Firstly, we define the properness profile of a quaternion random variable, which can be seen as the quaternion analogue of the complex circularity coefficients. The properness profile is a three-dimensional pure quaternion vector, which does not only measure the improperness degree of the quaternion random variable, but also provides the improperness distribution. Secondly, we prove that the quaternion ICA model can be identified up to the trivial scale and permutation ambiguities, and a residual quaternion mixture among the sources with rotational equivalent properness profiles, i.e., properness profiles related by a quaternion rotation. Finally, the main results of the paper are illustrated by means of some numerical examples.

Combining Multiband Joint Position-Pitch Algorithm and Particle Filters for Speaker Localization

TANIA Habib (Graz University of Technology, Austria); Harald Romsdorfer (Graz University of Technology, Austria)

Abstract: We present a combination of the multiband joint position-pitch (M-PoPi) estimation algorithm with the particle filtering framework to enhance the localization accuracy when tracking multiple concurrent speakers. A new likelihood function derived from the M-PoPi algorithm is proposed for the particle filter framework. The performance of the particle filter based tracker is compared with the M-PoPi algorithm. The proposed framework improves localization accuracy for all cases ranging from single upto three concurrent speakers.

Target Tracking in Mixed LOS/NLOS Environments Based on Individual TOA Measurement Detection

Lili Yi (NTU, Singapore); Sirajudeen Gulam Razul (Nanyang Technological University, Singapore); Zhiping Lin (NTU, Singapore); Chong Meng Samson See (DSO National Laboratories, Singapore)

Abstract: Non-line-of-sight (NLOS) signal propagation is one of the most important factors affecting the accuracy of localization or tracking especially in urban or indoor environments. This paper presents a method of alleviating the influence of the NLOS signal propagation using a novel individual measurement detection (IMD) approach based on the prior probability density function (pdf) of a moving target's state. The IMD approach can effectively identify line-of-sight (LOS) time-of-arrival (TOA) measurements from all mixed LOS/NLOS measurements. The extended Kalman Filter (EKF) algorithms is adopted to estimate the positions of the moving target using all selected LOS measurements. Simulation results show that the proposed approach outperforms some existing methods.

A Reference-Free Time Difference of Arrival Source Localization Using a Passive Sensor Array

Alon Amar (Delft University of Technology, The Netherlands); Geert Leus (Delft University of Technology, The Netherlands)

Abstract: Least squares source position estimation techniques from time difference of arrival measurements are based on choosing a reference sensor. Selecting different reference sensors may affect the positioning accuracy by a considerable amount. We suggest a closed-form least squares position estimation using all the available distinct time differences, which does not involve the selection of a reference sensor. The nonlinear terms, associated with the distances between the sensors and the source, are eliminated with an orthogonal projection matrix. Simulation results show that the proposed approach outperforms previous closed-form least squares solutions.

A Hierarchical Approach to Noise-Adaptive Estimation

Magnus Lundberg Nordenvaad (Luleå University of Technology, Sweden)

Abstract: This paper presents a noise-adaptive estimator for the linear model. The strategy is based on a hierarchical approach where in each step, a decreasing number of unbiased estimates for the parameter of interest is produced. In this way, the complexity is greatly reduced compared to standard estimators, like the adaptive maximum likelihood (AML) estimator. Also, since the method combines solutions to sub-problems of smaller dimensionality, the required size of the noise training data set is also reduced. As a result, the derived scheme performs better than AML for small sample support. The results are verified by simulations and show that the derived scheme is a very appropriate choice for a large class of problems with high dimensionality.

Fuzzy Triangle Contour Characterization by Subspace Based Methods of Array Processing

Haiping Jiang (Ecole Centrale Marseille, France); Julien Marot (Institut Fresnel, France); Caroline Fossati (Ecole Centrale Marseille, France); Salah Bourennane (Ecole Centrale Marseille, France)

Abstract: Fuzzy paradigm was considered from several aspects in image segmentation. For the first time, we derive a signal processing model out of an image which contains a fuzzy contour. We propose to adapt subspace-based methods of array processing which are originally dedicated to multiple incoherently distributed sources, to retrieve the orientation and spread parameters of fuzzy contours. A set of experiments performed on hand-made and real-world images show that the proposed methods estimate accurately the expected orientation and spread parameters of fuzzy contours, and exhibit a small computational load.

Adaptive Identification of Nonlinear MIMO Systems Based on Volterra Models with Additive Coupling

Angel Fernández-Herrero (Universidad Politécnica de Madrid, Spain); Carlos Carreras (Universidad Politécnica de Madrid, Spain); Javier Casajús (Universidad Politécnica de Madrid, Spain)

Abstract: Multiple-input multiple-output systems are increasingly important in a great number of fields, as is the case with telecommunications, robotics, biology, neuroscience, etc. In this paper, Volterra models are applied to a class of MIMO nonlinear systems, showing that linearity with respect to the coefficients ensures the availability of a global solution for the identification problem. The applicability of traditional learning algorithms, as Least-Mean-Square (LMS), is conditioned by eigenvalue spread, mainly dominated by nonlinear effects. This convergence issue and others are shown by means of a theoretical treatment and some examples.

Prequential Bayes Mixture Approach for Gaussian Mixture Order Selection

Keith Gilbert (University of Massachusetts Dartmouth, USA); Igal Bilik (University of Massachusetts, USA); John Buck (University of Massachusetts Dartmouth, USA); Karen Payton (University of Massachusetts Dartmouth, USA)

Abstract: This paper presents a modified prequential Bayes (MPB) model order estimator for Gaussian mixture models (GMM). The proposed MPB order estimator recursively updates the weighting for each order in a class of model orders from a time-invariant prior and the likelihood of the observed data for each model. This paper investigates both a maximum a posteriori (MAP) switching version and an affine version of the MPB order estimator. Simulations demonstrate that the MPB estimators fluctuate less than the minimum description length (MDL) criterion and the Akaike information criterion (AIC).

19:30 -23:00

Jerusalem tour

Wednesday, October 6

08:30 - 09:30

Plennary 5: Performance-Driven Information Fusion

Alfred O. Hero III, The University of Michigan, Ann Arbor, MI, USA

Abstract: Information fusion involves combining different information sources using models for the joint source distributions. It is a key component of multichannel sensor processing when there are multiple sensing modalities. Practical information fusion algorithms must approximate information theoretic quantities such as entropy and mutual information from finite number of samples from the sensors. Recently we have developed a framework, called performance-driven information fusion, that specifically accounts for the effect of finite sample estimation errors and bias on the information fusion task. The cornerstone for this framework is a large sample analysis of bias, variance, and probability distribution that applies to a general class of information divergence measures including /Csisz\'ar's / f-divergence, Shannon's mutual information, and Rényi's entropy. Under this framework information fusion algorithms can be implemented that incorporate error control, and for which one can optimize feature selection and specify optimal tuning parameters such as kernel bandwidth. This talk will introduce this framework and apply it to several applications in multichannel sensor processing.

09:30 - 10:45

High Dimensional Covariance Estimation

Session Chair: Ami Wiesel (Hebrew University in Jerusalem, Israel)

9:30 The Breakdown Point of Signal Subspace Estimation

Raj Rao Nadakuditi (University of Michigan, USA); Florent Benaych-Georges (University of Paris, France)

Abstract: The breakdown point of signal subspace methods, which is the SNR below which the algorithm's performance deteriorates dramatically, is intimately related to the breakdown point of PCA based signal subspace estimation.We shed new light on this breakdown point for a broad class of signal-plus-noise models, provide a transparent derivation that highlights its origin and verify the accuracy of the high-dimensional predictions with numerical simulations for a moderately sized system.

9:45 Hypothesis Testing in High-Dimensional Space with the Sparse Matrix Transform

Leonardo Bachega (Purdue University, USA); Charles Bouman (Purdue University, USA); James Theiler (Los Alamos National Laboratory Space and Remote Sensing Group, USA)

Abstract: This paper discusses the use of the Sparse Matrix Transform (SMT) to model the covariance structure of high-dimensional data in the likelihood ratio test used for hypothesis testing. The SMT has been shown to produce more accurate estimates of covariance matrices when the number of training samples n is much less than the number of dimensions p of the data. Several experiments with face recognition and hyperspectral images show that SMT-based hypothesis testing can be superior to other methods in at least two general aspects: First, the SMT-based method is more robust to the size of the training set, remaining accurate even when only a few training samples are available; Second, the total computation required to apply the method is very low, making it attractive for use in low-power devices, or in applications requiring fast computation.

10:00 On Toeplitz and Kronecker Structured Covariance Matrix Estimation

Petter Wirfalt (Royal Institute of Technology (KTH), Sweden); Magnus Jansson (KTH, Sweden)

Abstract: A number of signal processing applications require the estimation of covariance matrices. Sometimes, the particular scenario or system imparts a certain theoretical structure on the matrices that are to be estimated. Using this knowledge allows the design of algorithms exploiting such structure, resulting in more robust and accurate estimators, especially for small samples. We study a scenario with a measured covariance matrix known to be the Kronecker product of two other, possibly structured, covariance matrices that are to be estimated. Examples of scenarios in which such a problem occurs are MIMO-

communications and EEG measurements. When the matrices that are to be estimated are Toeplitz structured, we show our algorithms to be able to achieve the Cramer-Rao Lower Bound already at very small sample sizes.

10:15 Robust Shrinkage Estimation of High-dimensional Covariance Matrices

Yilun Chen (University of Michigan, USA); Ami Wiesel (Hebrew University in Jerusalem, Israel); Alfred Hero, iii (University of Michigan, USA)

Abstract: We address high dimensional covariance estimation for elliptical distributed samples. Specifically we consider shrinkage methods that are suitable for high dimensional problems with a small number of samples (large p small n). We start from a classical robust covariance estimator [Tyler(1987)], which is distribution-free within the family of elliptical distribution but inapplicable when $n<p$. Using a shrinkage coefficient, we regularize Tyler's fixed point iteration. We derive the minimum mean-squared-error shrinkage coefficient in closed form. The closed form expression is a function of the unknown true covariance and cannot be implemented in practice. Instead, we propose a plug-in estimate to approximate it. Simulations demonstrate that the proposed method achieves low estimation error and is robust to heavy-tailed samples.

10:30 Distributed Covariance Estimation in Gaussian Graphical Models

Ami Wiesel (Hebrew University in Jerusalem, Israel); Alfred Hero (University of Michigan, USA)

Abstract: We consider distributed covariance estimation in Gaussian graphical models. A typical motivation is learning the potential functions for inference via belief propagation in large scale networks. The classical approach based on a centralized maximum likelihood principle is infeasible, and suboptimal distributed alternatives which tradeoff performance with communication costs are required. We begin with a natural solution where each node performs independent estimation of its local covariance with its neighbors. We show that these local solutions are consistent, and can be interpreted as a pseudo-likelihood method. Based on this interpretation, we propose to enhance the performance by introducing additional symmetry constraints. We enforce these using the methodology of the Alternating Direction Method of Multipliers. This results in a flexible message passing protocol between neighboring nodes which can be implemented in large scale networks.

Low Rank Matrix Approximation

Session Chair: Aleksandar Dogandzic (Iowa State University, USA)

9:30 On Positioning via Distributed Matrix Completion

Andrea Montanari (Stanford University, USA); Sewoong Oh (Stanford University, USA)

Abstract: The basic question in matrix completion is to infer a large low-rank matrix from a small subset of its entries. Positioning refers to the task of inferring

the locations of n points from a subset of their distance. It turns out that positioning can be viewed as a matrix completion problem, although of a peculiar type. This paper discusses the applicability of matrix completion algorithms to the positioning problem.

9:45 Robust Principal Component Analysis?

Emmanuel Candés (Caltech, USA); Xiaodong Li (Stanford University, USA); Yi Ma (University of Illinois at Urbana-Champaign, USA); John Wright (Microsoft Research Asia, P.R. China)

Abstract: The problem of recovering a low-rank data matrix from corrupted observations arises in many application areas, including computer vision, system identification, and bioinformatics. Recently it was shown that low-rank matrices satisfying an appropriate {\em incoherence} condition can be exactly recovered from non-vanishing fractions of errors by solving a simple convex program, {\em Principal Component Pursuit}, which minimizes a weighted combination of the nuclear norm and the ℓ^1 norm of the corruption \cite. Our methodology and results suggests a principled {\em robust principal component analysis}, since they show that one can efficiently and exactly the principal components of a low-rank data matrix even when a positive fraction of the entries are corrupted. These results extend to the case where a fraction of entries are missing as well.

10:00 Subspace-Augmented MUSIC for Joint Sparse Recovery With Any Rank

Kiryung Lee (University of Illinois at Urbana-Champaign, USA); Yoram Bresler (University of Illinois, Urbana-Champaign. USA)

Abstract: We propose a robust and efficient algorithm for the recovery of the joint support in compressed sensing with multiple measurement vectors (the MMV problem). When the unknown matrix of the jointly sparse signals has full rank, MUSIC is a guaranteed algorithm for this problem, achieving the fundamental algebraic bound on the minimum number of measurements. We focus instead on the unfavorable but practically significant case of rank deficiency or bad conditioning. This situation arises with limited number of measurements, or with highly correlated signal components. In this case MUSIC fails, and in practice none of the existing MMV methods can consistently approach the algebraic bounds. We propose subspace-augmented MUSIC, which overcomes these limitations by combining the advantages of both existing methods and MUSIC. It is a computationally efficient algorithm with a performance guarantee.

10:15 Order-Preserving Factor Discovery from Misaligned Data

Arnau Tibau Puig (University of Michigan, France); Ami Wiesel (Hebrew University in Jerusalem, Israel); Alfred Hero, iii (University of Michigan, USA)

Abstract: We present a factor analysis method that accounts for possible temporal misalignment of the factor loadings across the population of samples. Our main hypothesis is that the data contains a subset of variables with similar but delayed profiles obeying a consistent precedence ordering relationship. Our model is motivated by the difficulty of gene expression analysis across subjects who have common patterns of immune response but show different onset times after a

uniform innoculation time of a viral pathogen. The proposed method is based on a linear model with additional degrees of freedom that account for each subject's inherent delays. We present an algorithm to fit this model in a totally unsupervised manner and demonstrate its effectiveness on extracting gene expression factors affecting host response using a flu-virus human challenge study dataset.

10:30 Nonparametric Bayesian Matrix Completion

Lawrence Carin (Duke University, USA)

Abstract: The Beta-Binomial processes are considered for inferring missing values in matrices. The model moves beyond the low-rank assumption, modeling the matrix columns as residing in a nonlinear subspace. Large-scale problems are considered via efficient Gibbs sampling, yielding predictions as well as a measure of confidence in each prediction. Algorithm performance is considered for several datasets, with encouraging performance relative to existing approaches.

10:45 - 11:00

Coffee break

11:00 - 12:00

Multichannel DSL Communication Systems

Session Chair: Amir Leshem (Bar-Ilan University, Israel)

11:00 Convergence Analysis of Adaptive Partial FEXT cancellation precoder for multichannel downstream VDSL

Ido Binyamini (Bar-Ilan University, Israel); Itsik Bergel (Bar Ilan University, Israel); Amir Leshem (Bar-Ilan University, Israel)

Abstract: In this paper we present and analyze a computationally-efficient, adaptive precoder for partial FEXT cancellation in downstream VDSL. The precoder is based on error signal feedback. We present conditions on the channel matrix and on the precoder parameter, and prove that if the conditions are satisfied then the precoder converges in expectation to the partial precoder presented by Cendrillon et al. Results are verified by simulations, which also show convergence in mean square error.

11:20 Frequency Domain Crosstalk Canceling Between VDSL2 Systems With Different Symbol Rates

Sigurd Schelstraete (Ikanos Communications, USA)

Abstract: ITU-T recently published recommendation G.993.5 for frequency-domain crosstalk cancellation, to be used in conjunction with VDSL2. This standard assumes identical symbol rates for all systems. After a brief review of G.993.5, we discuss an extension of frequency-domain crosstalk cancellation to cover the different symbol rates specified for VDSL2.

11:40 Vectored VDSL from a Practical Perspective

Ronen Yizhaq Gilad (Bar Ilan - Israel); Amit Priebatch (Bar Ilan, Israel); Elad Domanovitz (Bar Ilan, Israel); Ilan Sharfer (Bar Ilan, Israel); Avi. Matza (Bar Ilan, Israel); Eitan Tsur (Bar Ilan, Israel)

Abstract: Far End Crosstalk (FEXT) in a twisted pair cable is the most dominant noise impairment in short loops for VDSL2 systems. Its impact significantly reduces the VDSL2 modems performance and in some cases might reduce the modem throughput by more than 50%. Canceling the FEXT impact using Dynamic Spectral Management Level 3 (DSM L3, aka Vectoring aka FEXT Cancellation) is an emerging technology for high rates data traffic over copper (Up to 100Mbit/sec). We have developed an eight VDSL2 modems prototype with DSM L3 capabilities. In this article we introduce an overview of our system design and a variety of tests results that reflect the DSM L3 potential

12:00 - 13:30

Lunch

13:30 - 15:30

Poster Session III

A Recursive Model for Partially Correlated Chi^2 targets

Abner Ephrath (Rafael Inc., Israel)

Abstract: This work considers the problem of Chi^2 target detection in normal noise. The single pulse power (target RCS) is Chi^2 distributed with an arbitrary factor k. The correlation between pulses is determined by target dynamics. The sequence of target pulses is constructed using a recursive model, and the value of the correlation coefficient is derived. An approximation of 'strict sense Chi^2' is assumed for the probability density function of the sum of the integrated pulses. The form factor K of this density is calculated in terms of the correlation coefficient, number of integrated pulses and the factor k. By determination of the normalized threshold for the given Pfa (probability of false alarm), the probability of detection - Pd can be obtained. One way to do these calculations is using the "universal detection equation" suggested by D.K. Barton (7.2005).

The Polynomial Predictive Gaussian Mixture MeMBer Filter

Yin (Fudan University, P.R. China); Jian-qiu Zhang (Fudan University, P.R. China); Bo Hu (EE Dept., Fudan University, Shanghai, P.R.China); Qiyong Lu (Fudan University, Shanghai, PRC, P.R. China)

Abstract: We propose a novel multi-target tracking algorithm, called the polynomial predictive Gaussian mixture Multi-target Multi-Bernoulli filter (PPGM-MeMBer) filter. We firstly present a unified state space model where the state equation may describe any dynamics of the true targets, no matter linear or nonlinear and no matter we know them well or not, which is more common in practice. Then we apply the Gaussian mixture MeMBer (GM-MeMBer) filter to

the unified model. The analysis results show that the proposed PPGM-MeMBer filter can deal with situations when we do not know the targets dynamics well. The multi-target tracking simulation results verify the effectiveness of the proposed method.

Expected Likelihood Support for Deterministic Maximum Likelihood DOA Estimation

Yuri Abramovich (Defence Science and Technology Organisation (DSTO), Australia); Ben A. Johnson (JORN Technical Director, Australia)

Abstract: In this paper, the "expected likelihood" approach, previously introduced for the stochastic (unconditional) Gaussian case, is extended over the so-called deterministic (conditional) Gaussian case. Direction of arrival (DOA) estimation when arbitrary temporally correlated waveforms transmitted by point sources of interest impinge onto a uniformly spaced linear array is examined. Specifically, we introduce a normalized likelihood ratio that for the true DOAs have p.d.f.s that (for practical purposes) have weak enough dependence on these DOAs to be used in the expected likelihood approach. The utility of this approach is demonstrated by examples on DOA estimation in the so-called "threshold" region.

Covariance-Informed Detection in Compound-Gaussian Clutter Without Secondary Data

Francesco Bandiera (University of Salento, Italy); Olivier Besson (ISAE, France); Giuseppe Ricci (University of Salento, Lecce, Italy)

Abstract: We consider the problem of detecting a signal of interest in the presence of compound-Gaussian clutter, without resorting to secondary data in order to infer the clutter covariance matrix. Towards this end, we assume that both the texture τ and the speckle covariance matrix $\R$ are random variables with some a priori distributions. Marginalizing with respect to these variables, the probability density function of the observed primary data is derived, leading to a closed-form expression for the generalized likelihood ratio test (GLRT) of the problem at hand. Accordingly, the GLRT assuming that τ is deterministic is also derived. The two detectors are assessed through numerical simulations.

A Low Complexity STAP for Reverberation Cancellation in Active Sonar Detection

Neethu M Sasi (NIT Calicut, India); Pradeepa R (NPOL, India); Sarath Gopi (NPOL, India); P.S. Sathidevi (National Institute of Technology Calicut, India)

Abstract: One of the major problem for active sonar detector is the presence of reverberation. Since the reverberation has both spatially and temporally varying characteristics, a Space Time Adaptive Processing (STAP) technique is used to adapt the processing according to the varying environment. The contribution of this paper is a low complexity STAP scheme for reverberation cancellation in active sonar detection, making use of polyphase architecture based sampling rate conversion

A Migrating Target Indicator for Wideband Radar

François Deudon (University of Toulouse, France); François Le Chevalier (Thales Aerospace Division, France); Stéphanie Bidon (ISAE, France); Olivier Besson (ISAE, France); Laurent Savy (ONERA, France)

Abstract: The standard way to suppress clutter in narrowband radar is to use Moving Target Indicator (MTI) cancellation techniques. High Range Resolution (HRR) radars are becoming more and more important because they can detect and track targets more accurately. As for such radars the bandwidth is increased, the resolution is decreased and leads to target range migration over the coherent pulse interval (CPI). Due to this range walk, standard low resolution MTI processing is not adapted anymore to HRR MTI radar data. We propose here to extend the principle of the MTI processing to the wideband case. We refer to this method as the Migrating Target Indicator (MiTI), since it eliminates the non-migrating targets from the received signals.

A Computationally Efficient Blind Estimator Of Polynomial Phase Signals Observed By A Sensor Array

Alon Amar (Delft University of Technology, The Netherlands); Amir Leshem (Bar-Ilan University, Israel); Alle Jan van der Veen (Delft University, The Netherlands)

Abstract: Consider estimating the parameters of polynomial phase signals observed by an antenna array given that the array manifold is unknown (e.g., uncalibrated array). To date, only an approximated maximum likelihood estimator (AMLE) was suggested, however, it involves a multidimensional search over the entire coefficient space. Instead, we propose a two-step estimation approach, termed as SEparate-EStimate (SEES): First, the signals are separated with a blind source separation technique by exploiting the constant modulus property; Then, the coefficients of each polynomial are estimated using a least squares method from the unwrapped phase of the estimated signal. This estimator does not involve any search in the coefficient spaces and its computational complexity increases linearly with respect to the polynomial order, whereas that of the AMLE increases exponentially. Simulations show that the proposed estimator achieves the Cramer-Rao lower bound (CRLB) at moderate or high signal to noise ratio (SNR).

Passive Radar Imaging of Moving Targets with Sparsely Distributed Receivers

Ling Wang (Nanjing University of Aeronautics and Astronautics, P.R. China); Birsen Yazici (Rensselaer Polytechnic Institute, USA)

Abstract: We develop a novel passive image formation method for moving targets using measurements from a sparse array of receivers that rely on illumination sources of opportunity. We use a physics-based approach to model the wave propagation and develop a passive measurement model that expresses the measurement at each receiver in terms of the measurement at a different receiver. This model eliminates the need for knowledge about the transmitter locations and waveforms in the proposed image formation method. We formulate the image formation problem as a Generalized Likelihood Ratio Test (GLRT) for unknown target location and velocity using the proposed passive measurement model. We form the image in spatial and velocity space using the space- and velocity-resolved test-statistics.

Two-Dimentional Direction-of-Arrival Estimation of Coherent Signals with L-Sharped Array

Wang Guangmin (Xi'an Jiaotong University, P.R. China); Jingmin Xin (Xi'an Jiaotong University, P.R. China); Nanning Zheng (Xi'an Jiaotong University, P.R. China)

Abstract: In this paper, a new method is proposed for two-dimensional (2-D) direction-of-arrival (DOA) estimation of multiple narrowband coherent signals impinging on an L-shaped sensor arrays structured by two uniform linear arrays (ULAs). The coherency of incident signals is decorrelated through subarray averaging technique, and the null space is obtained through linear operator of two matrices formed from the cross-correlation matrix between the received data of two ULAs without eigendecomposition. The elevation angle and the quasi-azimuth angle are firstly decoupled and estimated, and the pair-matching of two groups of angles can be accomplished by using a novel method. Then by investigating the geometrical relation, the azimuth angle can be obtained. Furthermore the asymptotic mean-square-error (MSE) of the estimated elevation and azimuth angles are derived, and the effectively of the proposed method is verified through numerical examples.

Steering Vector Modeling for Polarimetric Arrays of Arbitrary Geometry

Mario Costa (Helsinki University of Technology, Finland); Andreas Richter (Aalto University, Finland); Visa Koivunen (Helsinki University of Technology, Finland)

Abstract: In this paper, the algebraic modeling of the steering vector for dual-polarized real-world arrays is addressed. The formalism provided by the wavefield modeling theory is extended to vector-fields such as completely polarized electromagnetic waves. In particular, compact expressions for decomposing the array steering vector in different orthonormal basis functions are proposed. Such decompositions are shown to be equivalent under mild conditions that typically hold in practice. These results allow for obtaining equivalent algebraic models of the steering vector for real-world arrays when calibration measurement data is available. Recent results on algebraic modeling of sensor arrays are generalized to vector-fields and unified. Simulations on DoA estimation using a real-world polarimetric array are carried out, validating our analytical results.

Parametric Joint Detection-Estimation of the Number of Sources in Array Processing

Noam Arkind (Weizmann Institute of Science, Israel); Boaz Nadler (Weizmann Institute of Science, Israel)

Abstract: Detection of the number of signals and estimation of their directions of arrival (DOAs) are fundamental problems in array processing. We present three main contributions to this problem, under the conditional model, where signal amplitudes are assumed deterministic unknown. First, we show that there is an explicit relation between model selection and the breakdown phenomena of the Maximum Likelihood estimator (MLE). Second, for the case of a single source, we provide a simple formula for the location of the breakdown of the MLE, using tools from the maxima of stochastic processes. This gives an explicit formula for the source strength required for reliable detection. Third, we apply these results and propose a new joint detection-estimation algorithm with state-of-theart performance. We demonstrate via simulations the improved detection performance of our algorithm, compared to other popular source enumeration methods.

15:30 - 16:30

Plenary 6: Direct Position Determination and Sparsity in Localization Problems

Anthony. J. Weiss, Tel Aviv University, Israel

Abstract: The most common methods for location of communications/radar transmitters are based on measuring a specified parameter such as signal Angle of Arrival (AOA), Time of Arrival (TOA), Received Signal Strength (RSS) or Differential Doppler (DD). The measured parameters are then used to estimate the transmitter location. Since the AOA/TOA/RSS/DD measurements are done independently, without using the constraint that all measurements must correspond to the same transmitter, the location estimate is suboptimal. Optimal localization is obtained by a single step which uses all the observations together in order to estimate the emitter position. We refer to single-step localization as Direct Position Determination (DPD). Although this principle is known for long time the signal processing community overlooked its potential benefits for long time. In this talk we will compare the DPD with two-step algorithms. We will show and explain why under ideal conditions such as high SNR the DPD is equivalent to two-step algorithms. However, under low SNR, jamming and other interferences the DPD provide better results. Further, we will show that DPD can overcome well known limitations on the number of sources associated with AOA. In the second part of the talk we will show how we can harness recent developments in sparsity theory to handle outliers in localization measurements. Surprisingly, under known limitations on the number of outliers, we can obtain the exact emitter location. Further, sparsity can also be used to find the location of sources by efficient linear programming or Second Order Cone programming.

19:30 - 23:00

Banquet and Jaffa tour (transportation to Tel-Aviv at 16:45)

Thursday, October 7

8:00 - 16:00

Hi-Tech Industry Visit