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Tuesday, December 15

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Sunday, December 13

Sunday, December 13, 09:30 - 10:50

T1: Robust statistical methods in signal processing: Recent advances

Tutorial 1 (Part 1)
Visa Koivunen and Abdelhak Zoubir
Room: Coral Gallery Ballroom

In this tutorial, recent advances and emerging topics on robust statistical methods for signal processing are presented. A signal processing procedure is statistically robust if it is not sensitive to departures from the assumed signal and noise models. The goal of a signal processing practitioner is then to design robust procedures that give a close to optimal performance at the nominal models and a highly reliable performance even in the worst case scenarios. We will provide a brief overview of basic concepts and tools needed in developing and analyzing robust methods. These tools facilitate devising signal processing techniques that are provably robust, and establishing their statistical properties. Examples illustrating these basic concepts are given in multivariate settings encountered in sensor array and multichannel signal processing. A commonly used assumption in signal processing is that observations are independent and identically distributed. Recent advances in robust statistical techniques for dependent data are presented. Applications, for example, in estimating the state of the power grid and the processing of time series data are provided. Statistically robust methods for processing large scale data (Big Data) are described as well. The volume and dimensionality of the data may be so high that it cannot be processed or stored in a single computing node. We describe a scalable, statistically robust and computationally efficient bootstrap method that is compatible with distributed processing and storage systems. Finally, statistically robust methods for processing sparse tensor-valued data are described with practical signal processing examples.

Sunday, December 13, 11:10 - 12:30

T1: Robust statistical methods in signal processing: Recent advances

Tutorial 1 (Part 2)
Visa Koivunen and Abdelhak Zoubir
Room: Coral Gallery Ballroom

Sunday, December 13, 14:00 - 15:20

T2: Decentralized estimation and tracking in wireless sensor networks

Tutorial 2 (Part 1)
Mark J. Coates and Michael G. Rabbat
Room: Coral Gallery Ballroom

During the past 15 years there has been a tremendous amount of work on communication- and/or energy-efficient methods for distributed signal processing. The aim of this tutorial is to provide and introduction and overview to state-of-the-art methods for decentralized estimation and tracking using gossip algorithms. We will begin with a review gossip algorithms for distributed averaging, focusing in particular on the push-sum and broadcast gossip algorithms which are especially attractive for use in wireless networks. Then we will discuss distributed particle filtering methods for estimation and tracking. We will highlight methods that have been developed during the past five years for reducing the communication overhead in the context of distributed particle filtering. A major challenge in the distributed setting is to fuse information contained in the measurements gathered at each sensor in a communication-efficient manner (i.e., without simply flooding all measurements over the network). We will discuss a variety of methods for approximating either the joint log likelihood function of the observations from all sensors, or for approximating the posterior distribution of the target state given all of the sensors' observations. Finally, we will present recent results on error bounds for distributed particle filters. Throughout, as running examples, we will consider the problems of tracking an underwater target target using a network of bearings-only sensors and tracking targets using signal strength measurements. We will conclude with a discussion of open problems and potential directions for future work.

Sunday, December 13, 15:40 - 17:00

T2: Decentralized estimation and tracking in wireless sensor networks

Tutorial 2 (Part 2)
Mark J. Coates and Michael G. Rabbat
Room: Coral Gallery Ballroom

Sunday, December 13, 17:00 - 19:00

SC: Student contest

Room: Coral Gallery Ballroom

Monday, December 14

Monday, December 14, 08:45 - 09:00

OC: Opening ceremony

Room: Coral Gallery Ballroom

Monday, December 14, 09:00 - 10:00

P1: Network processes

Plenary 1

José M. F. Moura
Room: Coral Gallery Ballroom
Chair: Cédric Richard (Université de Nice Sophia-Antipolis, France)

Traditionally, in engineering, dynamic systems are lumped systems described by an ordinary or partial differential or difference equation. In many recent applications of interest, for example, in large scale networked infrastructures, in social networks, in populations, systems are networks of possibly simple components or agents, and the system (network) state evolves through local interactions among its components. We explore methods to study the dynamics of these network processes and how to derive the system global behaviors that arise from the local interactions among the system components. (Work with June Zhang.)

Monday, December 14, 10:00 - 12:00

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Room: Poster Area
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P2: Graphs as signals

Plenary 2
Patrick Flandrin
Room: Coral Gallery Ballroom
Chair: Jean-Yves Tourneret (University of Toulouse & ENSEEIHT, France)

Graphs are ubiquitous for representing interactions in networks, be they physical, biological or social. Whereas numerous studies are intended to develop methods for analyzing signals over graphs, it will here be shown how the analysis of graph structures themselves can be performed by using tools borrowed from signal processing. The core of the approach is to build a distance map from the adjacency matrix of a graph, from which a collection of signals can be obtained thanks to a multidimensional scaling technique. Spectral features of the so-obtained signals can then be derived, with distinctive features for graph structures of different natures (regular, Erdös-Rényi, communities, scale-free, etc.). Various issues related to this perspective will be discussed, including efficient ways of inverting the transformation on the basis of a few components only, thus paving the way for « graph filtering ». An extension to dynamic graphs will also be considered, in which the time evolution of spectral features defines a matrix that can be factorized non-negatively. (Based on joint work with R. Hamon, P. Borgnat and C. Robardet.)

Monday, December 14, 17:30 - 19:30

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Tuesday, December 15

Tuesday, December 15, 09:00 - 10:00

P3: Distributed inference in the presence of Byzantines

Plenary 3
Pramod K. Varshney
Room: Coral Gallery Ballroom
Chair: Maria S. Greco (University of Pisa, Italy)

In this talk, we discuss the problem of Byzantines in the context of Distributed Inference Networks. Distributed inference networks have many applications including military surveillance, cognitive radio networks and smart grid. A distributed inference network typically consists of local sensors sending information to a central processing unit (known as the Fusion Center) that is responsible for inference. The network may contain malicious sensors that may engage in data falsification which can result in a wrong inference at the Fusion Center. Drawing parallel to the "Byzantine Generals Problem", the local sensors are the generals who try to make a decision in the presence of traitors called "Byzantines". We present an overview of recent research on this problem. Discussion includes the susceptibility of distributed inference networks to Byzantines, and then the possible protection of these networks through mitigation of Byzantines. A game theoretic formulation of the problem is also discussed. Several applications are considered and some avenues for further research are provided.

Tuesday, December 15, 10:00 - 12:00

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Room: Poster Area
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Tuesday, December 15, 16:30 - 17:30

P4: A probabilistic theory of Deep Learning

Plenary 4
Richard G. Baraniuk
Room: Coral Gallery Ballroom
Chair: Petar M. Djurić (Stony Brook University, USA)

A grand challenge in machine learning is the development of computational algorithms that match or outperform humans in perceptual inference tasks that are complicated by nuisance variation. For instance, visual object recognition involves the unknown object position, orientation, and scale in object recognition while speech recognition involves the unknown voice pronunciation, pitch, and speed. Recently, a new breed of deep learning algorithms have emerged for high-nuisance inference tasks that routinely yield pattern recognition systems with near- or super-human capabilities. But a fundamental question remains: Why do they work? Intuitions abound, but a coherent framework for understanding, analyzing, and synthesizing deep learning architectures has remained elusive. We answer this question by developing a new probabilistic framework for deep learning based on the Deep Rendering Model: a generative probabilistic model that explicitly captures latent nuisance variation. By relaxing the generative model to a discriminative one, we can recover two of the current leading deep learning systems, deep convolutional neural networks and random decision forests, providing insights into their successes and shortcomings, a principled route to their improvement, and new avenues for exploration.

Tuesday, December 15, 17:30 - 19:30

RS6: DOA and TDOA estimation

Room: Poster Area
Chair: Marius Pesavento (Technische Universität Darmstadt & Merckstr. 25, Germany)

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Wednesday, December 16

Wednesday, December 16, 09:00 - 10:00

P5: Adaptive superdirectivity of 2D oversampled HF antenna arrays: Theory, computational aspects and experimental results

Plenary 5
Yuri I. Abramovich
Room: Coral Gallery Ballroom
Chair: Fulvio Gini (University of Pisa, Italy)

In this talk, we present results of theoretical and experimental signal-to-external noise ratio (SENR) performance assessment for optimal (adaptive) beamforming in uniform rectangular (oversampled) antenna arrays (URA's) with inter-element spacing smaller than one half-wavelength. These arrays are considered as alternatives to a conventional one-dimensional uniform linear array (ULA) when in a quest for a significant enhancement of SENR the aperture of such a ULA becomes impractically long. In the case of uniform external noise distribution, the definitions of SENR gain with respect to an input (per element) SENR, and the antenna array directivity, coincide. Therefore, any SENR gains delivered by the optimum (vs. conventional) beamforming should be attributed to superdirective properties of these oversampled two-dimensional (2D) URA's. In addition to this uniform external noise distribution, we introduce several "tapered" noise distributions associated with the propagating phenomenology of high frequency (HF) noise over ionospheric channels in surfacewave (SW) and skywave over-the-horizon radars (OTHR). This talk also explores the Cramér-Rao bound (CRB) for azimuth (Az) and elevation (El) direction-of-arrival (DOA) estimation and specifies the role of superdirectivity in DOA estimation accuracy enhancement. We demonstrate that for relatively small antenna arrays used in SWOTHR applications, the oversampled 2D URA can significantly outperform 1D ULA's with the same number of elements and inter-element spacing. Oversampled 2D URA's utilized for advanced skywave OTHR applications deliver SENR and DOA estimation accuracy that approaches the performance of a 1D ULA with the same large number of antenna elements, but with impractical large apertures. Other benefits of 2D antenna arrays, associated with the improved selectivity in elevation, are not considered in this analysis which is focused on radar performance in strong external noise environments, typical for "night-time" skywave OTHR operation.

Wednesday, December 16, 10:00 - 12:00

RS7: Sparse signal processing and recovery

Room: Poster Area
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