# Parametric Estimation : Algorithms and Performance Analysis

Array processing has been a topic of interest for the last few decades with a large number of applications, in radio astronomy, radar, sonar, seismology, wireless communication, environmental monitoring contexts, etc. For example, in wireless communication, the sensor arrays are referred to smart antennas to locate the antenna beam on the devices by identifying the position of the mobile. In radio astronomy, a largely distributed sensors with a hierarchy of phased sensors form an array to capture the extraterrestrial radio signals in order to provide meaningful images.

Parametric estimation scheme provides solutions to alike mentioned problems. The main aim of parametric estimation scheme is to extract the hidden information of interest from the noisy signal measured. The information of interest is generally parametrized using some set of unknown variables (unknown parameters of interest), e.g., direction of arrivals and/or velocity of a target in the MIMO radar context. Based on such parametrized model, one has to apply estimation algorithms in order to estimate the unknown parameters of interest.

One can find a plethora of estimation schemes in the literature related to the aforementioned applications but only a few number of works studying the optimal performance associated with parametric model have been proposed. The study of the statistical performances of an estimator provides us a limit of the estimation accuracy. The knowledge of this limit is of great importance since it makes it possible to know if in a given context it is possible to respect certain performance requirements. It also makes it possible to know if, starting from a particular algorithm, an improvement is possible. Last, but not least, it allows us to design our system in order to obtain the best achievable accuracy. This performances analysis is generally performed with respect to two main measures. The first one is based on the mean square error, and the second one is based on the resolution limit.

This talk is dedicated to the statistical performances in array signal processing. More precisely, we will focus on lower bounds on the mean square error and on the statistical resolution limit.

i)- First, we present the study of some lower bounds on the mean square error related to the source localization in the near field context. Using the Cramér-Rao bound, we investigate the mean square error of the maximum likelihood estimator w.r.t. the direction of arrivals in the so-called asymptotic area (i.e., for a high signal to noise ratio with a finite number of observations.) Then, using other bounds than the Cramér-Rao bound, we predict the threshold phenomena.

ii)- Secondly, we focus on the concept of the statistical resolution limit, i.e., the minimum distance between two closely spaced signals embedded in an additive noise that allows a correct resolvability/parameter estimation. We define and derive the statistical resolution limit using the Cramér-Rao bound and the hypothesis test approaches for the mono-dimensional case. Then, we extend this concept to the multi-dimensional case. Finally, a generalized likelihood ratio test based framework for the multidimensional statistical resolution limit is given to assess the validity of the proposed extension.

The talk will be based on recent papers and will have the following structure. Note that we will introduce and compare different criteria not only from a theoretical viewpoint, but from a practical engineering perspective and we will emphasize their practical importance and usefulness.

1. Introduction
2. Basic Concepts of Performance Analysis
3. Performance Analysis in Terms of Mean Square Error
    1. Asymptotic Analysis
    2. Threshold Prediction
4. Performance Analysis in Terms of Statistical Resolution Limit
    1. Background on Statistical Resolution Limit
    2. Multidimensional Statistical Resolution Limit
5. System Design Using Performance Analysis Tools
6. Practical Engineering Perspective.
7. Conclusion

Speaker Biography – **Mohammed Nabil EL KORSO**

Dr. Mohammed Nabil EL KORSO received the Bsc degree in Mathematics and physics from ENPEI-National Preparatory School, Algeria in 2004. The M.Sc. in Electrical Engineering from the National Polytechnic School, Algeria in 2007. He obtained the Master Research degree in Signal and Image Processing from Paris-Sud XI University/Supélec, France in 2008. In, 2011, he obtained his PhD degree from Paris-Sud XI University/Supélec in the Modeling and Statistical Signal Processing team of the Laboratory of Signals and Systems. Between 2011 and 2012, he was a research scientist in the Communication Systems Group at Technische Universität Darmstadt, Germany. Currently, he is a temporary assistant professor at l'École normale supérieure de Cachan, France. Dr. Mohammed Nabil EL KORSO was the organizer of a special session entitled “Threshold limits in array processing : Performance analysis and methods” at the IEEE Asilomar Conf., Nov., 2012, Pacific Grove, CA, USA.

His research interests include statistical signal processing and estimation/detection theory with applications to array signal processing (performance analysis and direction of arrivals estimation), MIMO radar and radio astronomy (eye-fish observing with array radio telescope).