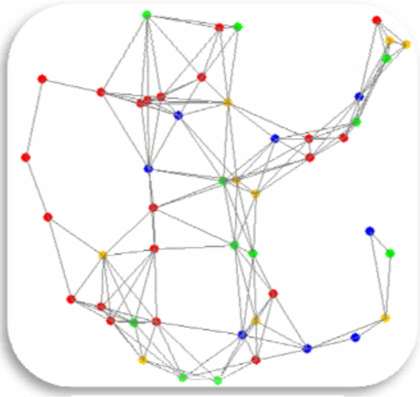
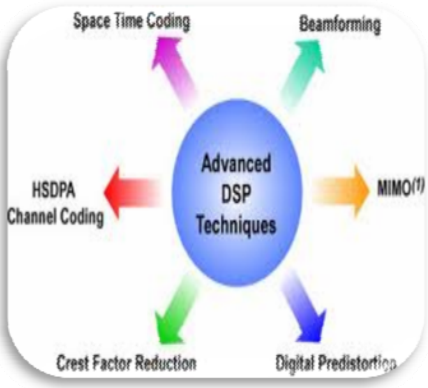
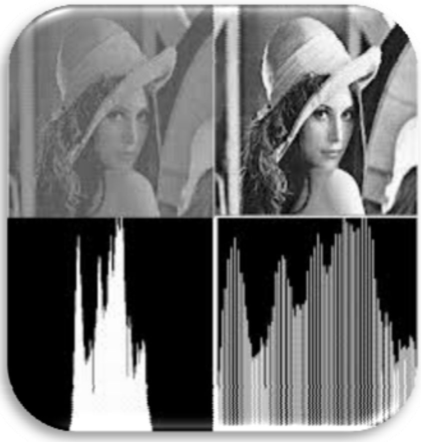
EE602 Statistical Signal Processing: Estimation and Detection Theory







Estimation and detection techniques form the bedrock of modern *signal processing* and *communication systems*. From the received signal equalization, radio channel estimation and synchronization process in mobile phones and wireless modems, to blur removal and image stabilization in image formation systems, intruder detection in RADAR systems, tomography based medical CT imaging systems, computer vision based face recognition and object/ person tracking systems, their applications can be found anywhere and everywhere. Further, the recently evolving paradigms of *cognitive radio* and *wireless sensor networks*, which define the cutting edge of current communication and sensing technologies, rely heavily on modern statistical signal processing. While primary user detection is a key step in cognitive radio networks, parameter estimation such as temperature and humidity etc from a *distributed* deployment of sensors is the central feature of a wireless sensor network. Also, the recently established field of compressive sensing has upended the traditional signal processing philosophies and has brought forth revolutionary possibilities in modern signal processing.

In this course, we will cover several topics starting from the basic concepts of random signals and probability to build complex estimators and detectors to suit a variety of scenarios. Each technique will be introduced with sufficient mathematical rigour to motivate the structure of the optimal statistical signal processing scheme followed by a thorough performance analysis. In the estimation theory part, we will cover in detail the Maximum Likelihood (ML) and Minimum Mean Squared Error (MMSE) estimators, which dominate the theory of modern signal processing. These will be supported by the theory of sufficient statistics, the Cramer-Rao Lower bound (CRLB) and low-complexity efficient linear estimators. This will be followed by advanced topics such as the expectation-maximization (EM) algorithm, sequential least squares to culminate in the epitome of modern statistical processing – The Kalman Filter.

In the detection theory part, we will start with the basics of maximum likelihood detection and the likelihood ratio test, building on the Neyman-Pearson criterion for optimal detection. This will then be followed by the matched filter detection and energy detectors for random signals along with the associated performance analysis. Subsequently, more advanced detectors based on the generalized llikelihood ratio test (GLRT) principle for deterministic and random signals will be discussed, succeeded by the advanced sequential, minimax and model change detectors.

The aim of this course is to expose the students to a mathematically rigorous treatment of modern signal processing, from both the point of view of a technology practitioner and also from the perspective of the latest research published in leading journals and conferences in areas such as image processing, cognitive radio and wireless sensor networks so as to motivate and enable students pursuing research in signal processing and communications.