Syrian Arab Republic

Higher Institute for Applied Sciences and Technology

HIAST

Course Specification Document

Title	Random Signal Processing

Credits	3.5 ECTS

Aims	This course aims to provide the student with the knowledge and skills related to random signal processing, particularly, communication systems and digital filtering theory, and studying the elementary concepts in stochastic estimation and noise reduction.

Intended learning outcomes

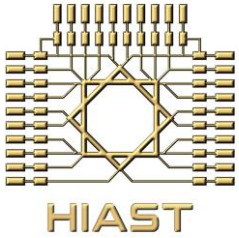
On successful completion of this course, the student will be able to:

- Identify dynamic models and output response equations to random input signals.
- Understand methods for mitigating the impact of noise on dynamic systems.
- Understand estimators in their various types and characteristics.

  Recognize linear and nonlinear filters (Wiener, Kalman filter, and extended Kalman filter).
- Apply theoretical concepts in analyzing the response relationships of dynamic systems in the frequency and time domains.
- Implement mathematical models on computer to study the effects of random signals and implement algorithms to mitigate their impact.
- Implement different estimators at their correct locations and study the primary and secondary differences between them.

Syllabus

- **Basic concepts in random signal processing:** the response of a linear system to a noisy signal in the time and frequency domains, the concept of the signal to noise ratio SNR, and the Equivalent Noise Bandwidth.
- **Identifying estimators and their characteristics**: Estimator properties, estimating the autocorrelation function and the covariance matrix, estimating the coefficients of the linear regression equation, estimating the power spectral density function.
- **Wiener and matched filter:** The equations of the matched filter and its applications, the equations of Weiner filter and its applications in noise reduction.
- **Minimum variance unbiased estimator (MVUE):** Calculation of the estimator and its properties, the Cramer-Rao Lower Bound in the scalar and vectorial cases.
- **Maximum likelihood estimator (MLE):** Analytical and numerical determination of the MLE.
- **Estimation by the method of moments:** Calculation of the estimator and the difference between it and the minimum dispersion and maximum likelihood estimators.



- **The least squares estimation (LSE):** Calculation of the estimator and its properties, sequential least squares estimation SLSE, Sequential nonlinear squares estimation NLSE, Gauss-Newton & Newton-Raphson methods and their applications, RBLS Rao-Blackwell-Lehmann-Scheffe (RBLS) Theorem for determining the estimator equation.
- **Linear models filtering:** The determination of the general estimator equation.
- **Kalman filter:** Description of the dynamic system and measurement equations, Equations governing the Kalman filter and Kalman filter applications.
- **Introduction to nonlinear filtering**: Introduction to extended Kalman filters EKF.