EECE6932-701 Detection and Estimation Theory

Spring 2022

<u>Tentative</u> Syllabus

Goal:

To establish the essential background in signal detection and estimation and statistical learning theory for engineering researchers and practitioners in areas such as communications, signal processing, machine learning, and control systems.

Course Description:

Hypothesis testing: Bayes, minimax and Neaman-Pearson detection; asymptotic relative efficiency; Karhunen-Loeve representation; structure and performance of optimal discrete and continuous time detection, sequential detection; maximum likelihood, minimum mean square-error, and maximum a posteriori estimation; sufficient statistics; generalized bounds on estimator performance; linear estimation; Kalman-Bucy and extended Kalman filtering; importance sampling; blind estimation; and elements of compressive sensing. Prerequisites: EECE 6020 or equivalent.

Instructor:

Professor Majeed M. Hayat; Room 289-A; Tel: 414-288-7772;
E-mail: majeed.hayat@marquette.edu

Classroom & time:

T & R: 5:00PM–6:15PM

Office hours:

By email, phone (505 328 1826) or MS-Teams, MW: 2:00–3:00.

Textbook:

Class notes (available on D2L), plus the following text:

H. V. Poor, *An Introduction to Signal Detection and Estimation*. Second Ed., Springer, 1994.

Topics:

1.

operating characteristics (ROC), locally optimum detectors.

2. **Discrete-time signal detection: Structure and performance analysis.** Ch. 3

Optimal coherent detection of deterministic signals in colored noise, signal selection, non-coherent detection, sequential detection, asymptotic relative efficiency.

3. **Continuous-time signal detection.** Ch. 5
   Grenander's Theorem, Mercer's Theorem, and the Karhunen-Loeve representation. Application to coherent detection.
4. **Parameter estimation.** Ch. 4
   Bayesian estimation: Maximum likelihood (ML), minimum-mean-square error, minimumabsolute-error, maximum a postriori (MAP) estimators.
   Sufficient statistics (class notes) and the Blackwell-Rao Theorem, Cramer-Rao bound.
   The information inequality.
   Further properties and extensions of the ML estimator. Recursive estimation.
5. **Signal estimation.** Chs. 5, 7
   Linear estimation: The orthogonality principle, Wiener-Kolmogorov filtering and prediction (continuous and discrete time).
   Discrete-time Kalman-Bucy filtering.
   Estimation of continuous-time–signal parameters.
   Some remarks on optimal and non-optimal nonlinear filtering.
6. **Detection of continuous-time stochastic signals in Gaussian noise.** Ch. 5 & notes
   Estimator-correlator structure of the likelihood ratio. Connection to matched filtering.
7. **Elements of large-deviation in detection and estimation.**
   Basic theorems; importance sampling; application to detection. Class notes from J. Bucklew's book
8. **Blind estimation.**
   Class notes from J. Bucklew's. .
9. **Elements of compressive sensing.**
   Class notes from review articles.

Computer usage:

A number of homework assignments require the use of Matlab.

Course requirements:

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- Students are encouraged to discuss their homework assignments with the sole goal of learning from one another. Each student, however, is expected to creates his/her own solution in an original manner.
- Unless related to course activities, the use of internet browsing, texting, facebooking, tweeting, instagramming, snap chatting, etc., during lectures (including online) is prohibited. It will prevent you from engaging with the class and will distract other students.