Department of Electrical and Computer Engineering
ECE 777: Detection and Estimation Theory

Description: The course covers various aspects of detection of signals as well as estimating signal parameters from noisy data. Topics include both simple and composite hypothesis testing; optimality criteria in signal detection (Bayes risk, minimum probability of error, and the Neyman-Pearson Lemma); the LRT, the GLRT, and the ROC; detecting deterministic as well as random signals in noise; subspace detectors for detecting signals with unknown parameters; the sufficient statistics, the CFAR detector, the concept of invariance and the UMPI detector; important parameter/spectrum estimation approaches, the CRLB and asymptotic results.

Prerequisites: (Co-requisite) ECE 601, ECE 640, ECE 673, and background in Linear Algebra

Textbook(s)/Materials required:

- L. L. Scharf, *Statistical Signal Processing: Detection, Estimation, and Time Series Analysis*, Addison Wesley, 1991.
- S. M. Kay, *Fundamentals of Statistical Signal Processing: Estimation Theory* (Vol.-I), *Detection Theory* (Vol.-II), Prentice Hall, 1993, 1998.
- Notes on lecture highlights and pointers to further reading for projects (to be posted in highlander pipeline course file folder).

Lecture Topics and Schedule:

Tentative Course Schedule	**Week**
Introduction & Motivation ➢ Statistical reasoning and its applications ➢ Estimation ➢ Detection ➢ Time series analysis	1
Rudiments of Linear Algebra and Matrix Analysis ➢ Vector spaces and linear independence ➢ Cholesky factorization and QR decomposition ➢ Matrices of special structures, properties, and asymptotic results ➢ SVD, subspaces, projections, rotations, and pseudo-inverses	2-3
Multivariate Statistics ➢ Important probability density functions ➢ MVN distribution and quadratic forms	3-4
Detection Theory ➢ Optimality criteria in signal detection ➢ Neyman-Pearson lemma, the LRT, and the ROC ➢ Sufficiency and Invariance ➢ The CFAR detectors and the Bayes detectors ➢ Signal detection examples ➢ The GLRT and UMPI detector	5-7

This course outline serves to provide a big picture of the course. Instructional materials such as textbooks, individual topics, and grading policy are subject to revision and changes by individual instructors.

Estimation Theory ➢ The optimality criteria in parameter/signal/spectrum estimation ➢ The MVU and MLE, linear and non-linear models	8-9
Estimation Theory – Cont'd ➢ The FIM, the CRLB, nuisance parameters, and asymptotic results ➢ The linear statistical model ➢ Parameter estimation, system identification, and estimation in structured correlation matrices	9-11
The Bayes Estimators ➢ Bayes risk, the prior, the posteriori, and the Bayes rules ➢ The linear statistical model ➢ The MAP ➢ The MMSE estimators and the low-rank approximations	12-13
Least Squares and the BLUE ➢ The linear model ➢ Subspaces, projections, and approximations ➢ The SVD, QR, and the Cholesky factorization in applications ➢ The BLUE	13-14
Final Project Presentation	15

Grading Policy:

Homework (20%), Mini-Projects (20%),

Mid-term Exam (30%), Final Project & Presentation (30%).

Honor Code: The NJIT Honor Code will be upheld, and any violations will be brought to the immediate attention of the Dean of Students.

Updates and Assignments are posted in highlander pipeline under ECE777 course file folder.

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Prepared by: H. Ge

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