TEL 602 Detection & Estimation

Spring 2023

School of ECE, Technical Univ. of Crete

Instructor: Dr. Aggelos Bletsas (aggelos@telecom.tuc.gr)

Lectures: Monday 17.00-19.00, Wednesday 18.00-20.00, **145P58, 2nd floor, Sciences Building**.

Class web site: eclass ($\rightarrow$ Select "TEL 602" from course list).

Office Hours: Friday $11.00 - 12.30$. Please RSVP.

Welcome to grad course TEL 602! This is a core graduate course, useful for people specialising in various aspects of engineering. Throughout the semester, we derive and discuss basic theoretical tools and provide concrete examples. Even though practical engineering problems will be analyzed, the course aims to develop solid problem solving skills applicable to more general settings.

It is hard to find a problem in digital communications, big data analytics, pattern recognition, radar/satellite engineering, bioinformatics, i.e., the broad area of signal processing that does not involve core detection and estimation theory! Students must feel comfortable with probability and linear algebra; however, all necessary background material is taught in the class.

Grading

1) Mid-term and Final written exam.
2) 6 Problem Sets.
3) Class participation, effort, as well as instructor's subjective assessment on how well the material has been grasped by the student.
4) Term project. You will be asked to present a research paper and reproduce its results or create a tangible, working apparatus; Talk to the instructor for valid topics - new research trends are also welcomed!

Important Notes

A. Written exams are open-book. You can bring whatever (non-electronic) material you want.

B. Cooperation in groups of $2-3$ students is permitted during problem sets preparation. However,

$$\texttt{cooperation} \neq \texttt{copying}.$$

You are responsible to provide your own report, indicating with whom you cooperated.

C. Problem sets are due online (at courses website). You are allowed to hand-write the answers, provided that your notes are crystal-clear and easy to read (i.e., no deciphering is needed). You do not have to latex your answers

(unless you really enjoy). For programming exercises, pls hand in your code too, which must be solely your own work!

D. Class starts exactly at the advertised time; Please try to come on time.

Syllabus

Week 1: Course Logistics, Examples; Revision of Linear Algebra and Probability.

Week 2: Binary Hypothesis Testing Examples; Sufficient Statistics, Receiver Operating Characteristic (ROC) & Neyman-Pearson Tests.

Week 3: ROC cont'ed, Gaussian Detection.

Week 4: M-ary Hypothesis Testing and Performance Analysis Bounds.

Week 5: Bayesian Estimation, Properties of Mean Squared Error and Linear Least Squares Estimators.

Week 6-7: Estimation of Non-random parameters, Cramer-Rao Bound (with proof); Examples.

Week 8: Uniform Minimum Variance Unbiased (UMVU) Estimators, RBLS Theorem.

Midterm!

Week 9: Asymptotic Behavior of Maximum Likelihood (ML) Estimators, BLUE Estimators.

Week 10: Composite Hypothesis Testing: UMP Tests, GLR Tests (GLRT) and Asymptotic Properties of GLRT.

Week 11: Standard Kalman/Wiener Filtering.

Week 12: Iterative parameter estimation: Hidden Markov Models (HMM) & Expectation-Maximization (EM).

Week 13: Introduction to non-parametric estimation: Particle Filtering.

Week 14: Project Presentations.

Bibliography

1. Bernard C. Levy, Principles of Signal Detection and Parameter Estimation, Springer 2008. Available online for free: https://link.springer.com/book/10.1007%2F978-0-387-76544-0
2. Steven M. Kay, Fundamentals of Statistical Signal Processing, Volumes I (Estimation) and II (Detection), Prentice Hall, 1993.
3. Harry L. Van Trees, Detection, Estimation, and Modulation Theory, Part I, John Wiley & Sons, 2001.
4. H. Vincent Poor, An Introduction to Signal Detection and Estimation, 2nd edition, Springer, 1994.
5. Athanasios Papoulis, Probability, Random Variables and Stochastic Processes, McGraw-Hill.
6. Lecture Notes.