COMMUNICATION ENGINEERING AND ELECTRONIC TECHNOLOGIES

(Lecce - Università degli Studi)

Insegnamento STATISTICAL SIGNAL PROCESSING

GenCod A002613

Insegnamento STATISTICAL SIGNAL PROCESSING

Insegnamento in inglese STATISTICAL SIGNAL PROCESSING

Settore disciplinare ING-INF/03

Corso di studi di riferimento COMMUNICATION ENGINEERING AND

Tipo corso di studi Laurea Magistrale

Crediti 9.0

Ripartizione oraria Ore Attività frontale: 81.0

Per immatricolati nel 2020/2021

Erogato nel 2020/2021

Anno di corso 1

Lingua INGLESE

Percorso PERCORSO COMUNE

Docente Giuseppe RICCI

Sede Lecce

Periodo Primo Semestre

Tipo esame Orale

Valutazione Voto Finale

Orario dell'insegnamento https://easyroom.unisalento.it/Orario

BREVE DESCRIZIONE DEL CORSO

Course Content.

Introduction: examples of statistical reasoning (7 hours).

Review of probability theory and rudiments of multivariate normal theory (7 hours). Solution to assigned problems (3 hours).

Estimation Theory: Classical and Bayesian Parameter Estimators (ML, LS, WLS, ILS, MAP, MMSE, and LMMSE estimators). How to measure the performance of an estimator. Cramer-Rao bounds (17 hours). Solution to assigned problems (18 hours). Computer generation of random vectors and moment estimation (3 hours).

Direction of arrival estimation: CML and MUSIC algorithm (3 hours). Matlab implementation of the MUSIC algorithm (3 hours).

Application of LMMSE estimation to filtering and beamforming. Minimum variance and minimum power distortionless beamformers. Linearly constrained minimum variance and minimum power beamformers. Generalized sidelobe canceler (5 hours).

Discrete-Time Kalman Filter. Extended Kalman Filter. Applications of Kalman Filter to tracking (8 hours).

Steepest-descent algorithm: derivation and analysis. Least-mean-square algorithm: derivation and analysis (4 hours).

Detection Theory: Neyman-Pearson Lemma, Testing of composite binary hypotheses, UMP tests, GLRT, Constant False Alarm Rate property (6 hours). Solution to assigned problems (2 hours).

PREREQUISITI

Prerequisites: sufficiency in calculus, probability theory, and linear algebra.

OBIETTIVI FORMATIVI

Overview.

This is a course in estimation and detection theory; it is aimed at providing principles and tools to solve problems in signal processing, radar, sonar, and communication. It will also serve as the necessary prerequisite for more advanced courses in communication engineering.

Learning Outcomes.

Knowledge and understanding

After the course the student should understand the main aspects of estimation and detection theory and in particular

*classical and Bayesian approaches to estimation; strategies to solve binary hypotheses tests (Neyman-Pearson, GLRT).

*The Kalman filter and the extended Kalman filter and their use to solve simplified tracking problems.

Applying knowledge and understanding

After the course the student should be able to

*formulate and solve parameter estimation problems and derive corresponding Cramer-Rao lower bounds.

*Formulate and solve detection problems resorting to the optimum (i.e., Neyman-Pearson test or UMP test) if possible or to a suboptimum one (GLRT).

*Evaluate the performance parameters and discuss complexity issues associated with different solutions.

Making judgements

Students should acquire the ability to compare pros and cons of different approaches to the solution of a specific problem through examples and problems.

Communication

The ability to communicate on technical topics should be acquired by discussing in a rigorous way not only concepts and tools of detection and estimation theory, but also the adopted solution to a specific problem.

Learning skills

Selected problems will be proposed that require elaborating on introduced concepts and methods, also with the help of selected readings suggested by the instructor (from the list of references). Identifying solutions to non trivial problems will be important to be ready for autonomous lifelong learning.

METODI DIDATTICI

Lectures, exercises, and computer projects. Problem-solving skills are of paramount importance and are gained via assigned homeworks.

MODALITA' D'ESAME

Examination.

<u>Written exam</u>. The exam consists of two cascaded parts (maximum overall duration: two hours and a half):

the first part is closed book (suggested duration 50 minutes); the student is asked to illustrate two theoretical topics; it is aimed to verify to what extent the student has gained knowledge and understanding of the selected topics of the course and is able to communicate about his/her understanding (the maximum score for illustrating each topic is typically 5/30);

the second part, that starts when the student has completed the first part, is open book and requires solving two (or three) problems; it is aimed to determine to what extent the student has: 1) the ability to identify and use data to formulate responses to well-defined problems, 2) problem solving abilities and the capacity to integrate different concepts and tools (the maximum score for the solution of each problem is typically 10/30 or 6-7/30 if the second part of the exam requires solving three problems).

APPELLI D'ESAME	
ALTRE INFORMAZIONI UTILI	**Office Hours:** by appointment; contact the instructor by email or at the end of class meetings.

PROGRAMMA ESTESO

Statistical Signal Processing - Master degree (LM) in Communication Engineering and Electronic Technologies (Fall semester)

Overview.

This is a course in estimation and detection theory; it is aimed at providing principles and tools to solve problems in signal processing, radar, sonar, and communication. It will also serve as the necessary prerequisite for more advanced courses in communication engineering.

Learning Outcomes.

Knowledge and understanding

After the course the student should understand the main aspects of estimation and detection theory and in particular

*classical and Bayesian approaches to estimation; strategies to solve binary hypotheses tests (Neyman-Pearson, GLRT).

*The Kalman filter and the extended Kalman filter and their use to solve simplified tracking problems.

Applying knowledge and understanding

After the course the student should be able to

*formulate and solve parameter estimation problems and derive corresponding Cramer-Rao lower bounds.

*Formulate and solve detection problems resorting to the optimum (i.e., Neyman-Pearson test or UMP test) if possible or to a suboptimum one (GLRT).

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Detection Theory: Neyman-Pearson Lemma, Testing of composite binary hypotheses, UMP tests, GLRT, Constant False Alarm Rate property (6 hours). Solution to assigned problems (2 hours).

Prerequisites: sufficiency in calculus, probability theory, linear algebra, digital communication theory.

Examination.

Written exam. The exam consists of two cascaded parts (maximum overall duration: two hours and a half):

the first part is closed book (suggested duration 50 minutes); the student is asked to illustrate two theoretical topics; it is aimed to verify to what extent the student has gained knowledge and understanding of the selected topics of the course and is able to communicate about his/her understanding (the maximum score for illustrating each topic is typically 5/30);

the second part, that starts when the student has completed the first part, is open book and requires solving two (or three) problems; it is aimed to determine to what extent the student has: 1) the ability to identify and use data to formulate responses to well-defined problems, 2) problem solving abilities and the capacity to integrate different concepts and tools (the maximum score for the solution of each problem is typically 10/30 or 6-7/30 if the second part of the exam requires solving three problems).

Office Hours: By appointment; contact the instructor by email or at the end of class meetings.

References.

[1] Handouts (in progress).

[2] L. L. Scharf, ``Statistical Signal Processing: Detection, Estimation, and Time Series Analysis,'' Addison-Wesley, 1991.

[3] H. L. Van Trees, ``Detection, Estimation and Modulation Theory,'' Part. 1, John Wiley & Sons, 1968.

[4] H. L. Van Trees, ``Optimum Array Processing. Part. 4 of Detection, Estimation, and Modulation Theory,'' John Wiley & Sons, 2002.

[5] S. M. Kay: ``Fundamentals of Statistical Signal Processing: Estimation Theory,'' Volume I, Prentice-Hall, 1993.

[6] S. M. Kay: ``Fundamentals of Statistical Signal Processing: Detection Theory,'' Volume II, Prentice-Hall, 1998.

[7] Y. Bar-Shalom, T. E. Fortmann, ``Tracking and Data Association, Academic Press'', 1988.

[8] Y. Bar-Shalom, X., Rong Li, T. Kirubarajan, ``Estimation with Applications to Tracking and Navigation. Theory Algorithms and Software,'' John Wiley & Sons, 2001.

[9] S. Haykin, ``Adaptive Filter Theory,'' Prentice-Hall, 1996.

TESTI DI RIFERIMENTO

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