Universitat Autònoma de Barcelona

Statistical Signal Processing 2016/2017

Code: 42845
ECTS Credits: 6

Degree	Type	Year	Semester
4313797 Telecommunications Engineering	OB	1	1

Contact

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Use of languages

Principal working language: english (eng)

Teachers

Marco Antonio Bara Iniesta

Prerequisites

For students who have been admitted indirectly to the master (e.g. those who must attend complementary courses), they should have already passed the course on "Tractament digital del senyal" (TDS) offered within the B.Sc. degree on Telecommunication Systems Engineering (i.e. "Grau d'Enginyeria en Sistemes de Telecomunicació").

Objectives and Contextualisation

The goal of this course is to introduce advanced techniques in statistical signal processing with applications in the domain of telecommunication systems.

Skills

- Capacity for applying theory of information methods, adaptative modulation and channel coding as well as advanced techniques for digital signal processing in telecommunications and audiovisual systems.
- Capacity for critical reasoning and thought as means for originality in the generation, development and/or application of ideas in a research or professional context.
- Capacity for designing radionavegation, positioning systems and radar systems.
- Capacity to integrate new technologies and systems developed within telecommunications engineering in general and in broader, multidisciplinary contexts such as bioengineering, photovoltaic conversion, nanotechnology, telemedicine
- Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context
- Student should possess the learning skills that enable them to continue studying in a way that is largely student led or independent
- Students should know how to apply the knowledge they have acquired and their capacity for problem solving in new or little known fields within wider (or multidisciplinary) contexts related to the area of study
- Students should know how to communicate their conclusions, knowledge and final reasoning that they hold in front of specialist and non-specialist audiences clearly and unambiguously

Learning outcomes

1. Analyse the implications at system level of the use of statistical signal processing techniques.
2. Apply advanced mathematical methods for the resolution of problems related to statistical signal processing.
3. Capacity for critical reasoning and thought as means for originality in the generation, development and/or application of ideas in a research or professional context.
4. Develop and evaluate signal detection techniques with applications in positioning and radar systems.
5. Develop statistical filtering systems aimed at synchronisation, equalisation and detection in communications receivers
6. Make a statistical classification of signals and random processes of telecommunications systems.
7. Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context
8. Student should possess the learning skills that enable them to continue studying in a way that is largely student led or independent
9. Students should know how to apply the knowledge they have acquired and their capacity for problem solving in new or little known fields within wider (or multidisciplinary) contexts related to the area of study
10. Students should know how to communicate their conclusions, knowledge and final reasoning that they hold in front of specialist and non-specialist audiences clearly and unambiguously

Content

1. Fundamentals of classical estimation theory

- Estimation in signal processing
- Performance lower bounds.
- Review of estimators (optimal and suboptimal).
- Review of statistical filtering (Wiener and adaptive filters).
- Recursive least squares (RLS).

2. Bayesian estimation theory

- Bayesian estimators (general and linear).
- Kalman filter.
- Bayesian bounds.
- Case of study: Kalman filter for carrier synchronization.

3. Detection theory

- Detection in signal processing.
- Detection performance (error probabilities, ROC).
- Detection criteria for completely known statistics (Neyman-Pearson, Bayes risk).
- Detection criteria in the presence of unknown parameters (GLRT, Rao, Wald, LMP).
- Sequential detection (SPRT, CUSUM).
- Case of study: Radar signal detection.

4. Applications of statistical signal processing

- Digital SAR image processing

Methodology

Activities at class:

- Theoretical classes: development of the theoretical contents of this course.
- Exercises solved by the instructor with participation of the students.
- Written evaluation tests.

Student self-learning activities:

- Study of the theoretical and practical contents of this course.
- Preparation of exercises and other homework.
- Preparation of the evaluation tests.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Theoretical lectures	39	1.56	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Type: Supervised			
Appointments	13	0.52	9, 10
Type: Autonomous			
Study	90	3.6	1, 2, 3, 4, 5, 6, 8

Evaluation

The marks of the exams will be averaged leading to the following course mark:

CourseMark = 0.3 x markExam1 + 0.3 x markExam2 + 0.2 x markExam3 + 0.2 markHomework

The course will be declared to be passed when CourseMark >= 5.

If CourseMark < 5, students will have a second chance to pass the course by doing a final exam covering all or just those parts of the syllabus that have been failed.

If CourseMark >= 5, students can also attend the final exam if they wish to improve their marks. They can do the exercises of the final exam corresponding to all, or those parts of the syllabus where they want to improve the mark. The final course mark will be computed as the maximum between the course mark they previously had, and the new one they have obtained.

Students missing all three exams will be declared to be "not evaluable" in the final mark of this course.

No second chance will be given to the homework mark.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Exam 1 (chapters 1 and 2 of the syllabus)	30%	2	0.08	1, 2, 6, 7, 8
Exam 2 (chapter 3 of the syllabus)	30%	2	0.08	1, 2, 3, 4, 5, 6, 8, 9, 10
Exam 3 (chapter 4 of the syllabus)	20%	2	0.08	1, 3, 6, 7, 8, 9, 10
Homework (chapter 2)	20%	2	0.08	1, 2, 5, 9, 10

Bibliography

Basic bibliography:

- S. Kay, Fundamentals of statistical signal processing. Estimation theory, vol. I, Prentice-Hall, 1993.
- S. Kay, Fundamentals of statistical signal processing. Detection theory, vol. II, Prentice-Hall, 1998.
- M. S. Grewal, A. P. Andrews, Kalman filtering: theory and practice using Matlab, John Wiley & Sons, 2001.

Complementary bibliography:

- H. L. Van Trees, K. L. Bell, Bayesian bounds for parameter estimation of nonlinear filtering/tracking, IEEE Press, 2007.
- B. C. Levy, Principles of signal detection and parameter estimation, Springer, 2008.