UAB
Universitat Autònoma de Barcelona

Statistical Signal Processing

Code: 42845
ECTS Credits: 6

2025/2026

Degree	Type	Year
Telecommunication Engineering	OB	1

Contact

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Teachers

Francesc Xavier Mestre Pons

Teaching groups languages

You can view this information at the end of this document.

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 to telecommunication systems based on multiple sensors.

Competences

- 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

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- 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. Multi-sensor signal model

- Baseband signal model and analytic signal.
- Far field wave front model. Narrowband approximation.
- Direction of arrival. Spatial covariance matrix.

2. Spatial filtering

- Space-time filtering and beamforming.
- Design of spatial reference beamformers.
- Capon beamformer. Direction of arrival estimation.
- Design of time reference beamformers.
- Adaptive filtering: LMS and RLS.

3. Source detection and tracking

- Detection theory (error probabilities, ROC).
- Detection criteria for completely known statistics (Neyman-Pearson).
- Detection criteria in the presence of unknown parameters (GLRT).
- Parameter tracking: Kalman filter

4. Multiple-input multiple-output (MIMO) processing: spatial diversity and multiplexing

- Array processing in multipath fading channels.
- Spatial diversity at the transmitter and at the receiver.
- Space-time coding.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	37	1.48	1, 2, 3, 6, 4, 5, 9, 10, 8, 7
Type: Supervised			
Tutorials	15	0.6	9, 10
Type: Autonomous			
Study	88	3.52	1, 2, 3, 6, 4, 5, 8

Student self-learning activities:

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

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exam 1	33%	2	0.08	1, 2, 6, 8, 7
Exam 2	33%	2	0.08	1, 2, 3, 6, 4, 5, 9, 10, 8
Practical exercises	34%	6	0.24	1, 2, 5, 9, 10

Computation of the continuous evaluation score:

The scores of the different evaluation tests are averaged to obtain the continuous evaluation score according to:

Continuous evaluation score (CE) = max (0.5 x markExam1 + 0.5 x markExam2, 0.33 x markExam1 + 0.33 x markExam2 + 0.34 x markPracticalExercises)

Computation of the final course score:

If AC >= 5, the student has passed the continuous evaluation and the final score of the course is the continuous evaluation score defined above.

If AC < 5, the student has failed the continuous evaluation. In this case, the student has the option of taking a second-chance exam that will take place within the period of exams planned by the degree in January / February. The mark of the second-chance exam replaces the mark of the continuous evaluation exams, and the final course mark will be calculated following the same formula as for the continuous evaluation.

It must be borne in mind, however, that the practical exercises cannot be recovered.

Students who do not participate in the exams will be declared "not evaluable" in the final grade of the course.

This course does not consider the single evaluation system (i.e. "sistema d'avaluació única").

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.
- Don H. Johnson, Dan E. Dudgeon, *Array signal processing, concepts and techniques*, Prentice Hall, 1993.
- S. Haykin, *Array signal processing*, Prentice Hall, Englewood Cliffs, 1985.
- H. L. Van Trees, *Optimum array processing, part IV: Detection, estimation and modulation theory*, New York, Wiley 2002.
- E. Larsson, P. Stoica, *Space-time block coding for wireless communications*, Cambridge University Press, UK, 2003.

Software

MATLAB

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(TEmRD) Teoria (màster RD)	1	English	first semester	afternoon