# Universida<sub>de</sub>Vigo

## IDENTIFYING DATA
### Statistical Signal Processing

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|---|---|---|---|---|
| Subject | Statistical Signal Processing | | | |
| Code | V05M145V01303 | | | |
| Study programme | Máster Universitario en Ingeniería de Telecomunicación | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 5 | Optional | 2nd | 1st |
| Teaching language | English | | | |
| Department | | | | |
| Coordinator | López Valcarce, Roberto | | | |
| Lecturers | López Valcarce, Roberto | | | |
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| Web | http://moovi.uvigo.gal | | | |
| General description | Statistical Signal Processing, encompassing both estimation and detection theory, can be found at the core of many decision-making and information-extracting systems, including communications, audio and image processing, biomedicine, radar, and big data systems, just to name a few. In this course an introduction to the basics of estimation and detection theory is provided. Since the course is targeted to electrical engineering students, the focus is on the development of practical estimation and detection algorithms amenable to implementation in digital processing systems. | | | |

## Skills

| Code | |
|---|---|
| B4 | CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields. |
| B8 | CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge. |
| C23 | CE23/PS3 Ability to apply methods of statistical processing of signal communications systems and audiovisual. |

## Learning outcomes

| Expected results from this subject | Training and Learning Results |
|---|---|
| Ability to apply statistical estimation techniques in communications and multimedia systems | C23 |
| Ability to apply statistical detection techniques in communications and multimedia systems | C23 |
| Ability to determine and interpret fundamental limits in estimation and detection problems | B4 C23 |
| Ability to evaluate the performance of estimation and detection techniques, by analytical as well as by Monte Carlo simulation methods | B8 C23 |

## Contents

| Topic | |
|---|---|
| Part 1: Parameter Estimation | - The statistical estimation problem. Performance metrics: bias, variance, MSE. Minimum Variance Unbiased Estimator (MVUE). |
| | - Fisher Information and Cramer-Rao bound. Slepian-Bangs formula. |
| | - Best Linear Unbiased Estimator (BLUE) and Maximum Likelihood Estimator (MLE): definition, properties, and examples. |

| Part 2: Detection Theory | - Hypothesis tests: types. Performance metrics: false positives and false negatives. ROC curves.<br>- Neyman-Pearson theorem: likelihood ratio.<br>- Detection under the Bayesian philosophy: probability of error, risk, optimum detector.<br>- Examples: deterministic and random signals |
|---|---|

## Planning

|  | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 21 | 23 | 44 |
| Practices through ICT | 7 | 7 | 14 |
| Autonomous problem solving | 0 | 28 | 28 |
| Simulation | 0 | 25 | 25 |
| Objective questions exam | 2 | 12 | 14 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

|  | Description |
|---|---|
| Lecturing | Presentation of main topics, possibly with audiovisual aids. Skills involved: CG4, CG8 |
| Practices through ICT | Computer-based simulation in the lab, under the MATLAB programming environment, of statistical signal processing applications to communications and multimedia, via Monte Carlo methods. Performance analysis. Skills involved: CG8, CE23 |
| Autonomous problem solving | Students will be given a series of short homework assignments throughout the course that they should turn in by the set deadline. Skills involved: CG4, CG8, CE23 |
| Simulation | Computer-based simulation of statistical signal processing applications to communications and multimedia, via Monte Carlo methods. Performance analysis. Skills involved: CG8, CE23 |

## Personalized assistance

| Methodologies | Description |
|---|---|
| Lecturing | Student aid will be provided during office hours by appointment, as well as on-line (email). |
| Practices through ICT | Student aid will be provided during lab hours and office hours by appointment, as well as on-line (email). |

## Assessment

|  | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Autonomous problem solving | Students will be given a series of short homework assignments throughout the course that they should turn in by the set deadline. | 40 | B4 B8 | C23 |
| Objective questions exam | Comprehensive test in which students must solve a number of exercises or problems. | 60 | B4 B8 | C23 |

## Other comments on the Evaluation

Students may choose one of the following two assessment options:

1) Continuous assessment: Final grade will consist of:

- comprehensie test (up to 6 points)

- homework assignments (up to 4 points)

A minimum grade of 30% in the comprehensive test is required in order to pass the course. Otherwise, the overall grade will directly be that of the comprehensive test.

Homework grades from the first call will be kept for the second call, in which the student will be allowed to retake the comprehensive test. Students assume continuous assessment with the submission of any homework assignment.

2) One-shot assessment: The final grade is the one achieved in the comprehensive test, for both the first and second call.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the reports or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

## Sources of information

**Basic Bibliography**

S. M. Kay, **Fundamentals of Statistical Signal Processing, vol. I: Estimation Theory**, 1, Prentice Hall, 1993
S. M. Kay, **Fundamentals of Statistical Signal Processing, vol. II: Detection Theory**, 1, Prentice Hall, 1998

**Complementary Bibliography**

L. L. Scharf, **Statistical signal processing: detection, estimation and time series analysis**, 1, Pearson, 1991
T. K. Moon, W. C. Stirling, **Mathematical Methods and Algorithms for Signal Processing**, 1, Pearson, 1999
IEEE, **http://ieeexplore.ieee.org/**,

## Recommendations

**Subjects that are recommended to be taken simultaneously**

Communication Advanced Systems/V05M145V01302

**Subjects that it is recommended to have taken before**

Advanced Digital Communications/V05M145V01204
Signal Processing in Communications/V05M145V01102