Learning objectives of the subject:
The course introduces the student to important statistical signal processing techniques and their application in digital
communications and speech and image processing. The course is organized into three modules covering the main aspects of the estimation, tracking and detection theories and their application to practical problems. For every module, classes are divided into classroom lectures, exercises and presentation of illustrative applications.

Learning results of the subject:
(i) To achieve a solid background on Statistical Signal Processing (estimation theory, detection theory and adaptive filtering) from the theoretical and applied perspectives.
(ii) Ability to design optimal and suboptimal estimators following classical and Bayesian approaches, as well as to evaluate the theoretical Cramér-Rao Lower Bound.
(iii) Ability to solve problems in which the unknown parameter (to estimate) evolves in time according to a dynamic or state model requiring the design of adaptive filters to track its value.
(iv) Ability to formulate simple binary and multiple hypothesis testing problems including the realistic situation in which there are some unknowns in the signal model (the pdf associated to the different hypotheses is not completely known).
(v) Gain experience reading and understanding published journal and conference articles related with the topic.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 39h</th>
<th>31.20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study:</td>
<td>86h</td>
<td>68.80%</td>
</tr>
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</table>
# Content

<table>
<thead>
<tr>
<th>Estimation Theory and Applications</th>
<th>Learning time: 43h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 13h 30m</td>
</tr>
<tr>
<td></td>
<td>Self study: 30h</td>
</tr>
</tbody>
</table>

**Description:**
1.1 Minimum Variance Estimation and Crámer-Rao Lower Bound
1.2 Maximum Likelihood Estimation
1.3 Bayesian Estimation
1.4 Applications in communications, speech processing and/or image processing

<table>
<thead>
<tr>
<th>Adaptive Filtering and Tracking</th>
<th>Learning time: 31h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 1h</td>
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<tr>
<td></td>
<td>Self study: 30h</td>
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</tbody>
</table>

**Description:**
2.1 Recursive Least Squares
2.2 Kalman filter
2.3 Sequential Monte Carlo Methods
2.4 Applications in communications, speech processing and/or image processing

<table>
<thead>
<tr>
<th>Detection Theory and Applications</th>
<th>Learning time: 38h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 12h</td>
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<tr>
<td></td>
<td>Self study: 26h</td>
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</tbody>
</table>

**Description:**
3.1 Detection theory when the pdf is known
3.2 Detection of deterministic signals
3.3 Detection of random signals
3.4 Detection theory when the pdf is not completely known
3.5 Applications in communications, speech and/or image processing

## Qualification system

Final examination: 50%
Individual assessments: 50%
**Regulations for carrying out activities**

**Exercises:**
Each chapter proposes a set of exercises to strengthen the theoretical knowledge. The exercises will be solved in class or proposed as individual work.

**Individual project:**
Students will develop a supervised project consisting in programming, simulating and evaluating some of the signal processing algorithms presented in the course using some language as C or MATLAB.

**Oral presentation:**
The project described above will be presented in class. This project (development and presentation) constitutes the 50% of the qualification.

**Extended answer test (Final examination):**
Final examination (written examination). The exam constitutes the 50% of the qualification.

**Bibliography**

**Basic:**

**Complementary:**

**Others resources:**
- **Hyperlink**
  - Slides and Exercices
  - Resource in Atenea