230092 - PSAVC - Signal Processing for Communications and Audiovisual Systems

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2017
Degree: BACHELOR'S DEGREE IN TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
ECTS credits: 6  Teaching languages: Catalan

Teaching staff

Coordinator: Pages Zamora, Alba Maria
Riba Sagarra, Jaume
Others: Vidal Manzano, Jose
Najar Marton, Montserrat

Requirements

Prerequisite: IPSAV and ICOM
Corequisite: AMT

Degree competences to which the subject contributes

Generical:
12 CPE N2. They will be able to identify, formulate and solve engineering problems in the ICC field and will know how to develop a method for analysing and solving problems that is systematic, critical and creative.

Teaching methodology

Application lectures
Lectures
Group work
Personal work
Short answer test
Exams with exercises (Control and Final Exam)

Learning objectives of the subject

- To plan and use the needed information in order to develop a project or academic work, based on a critical appraisal of the used information resources.
- To apply the acquired skills to carry out a task. To identify the need for continuous learning and for the design of an strategy to carry out that task.
- To identify, model and raise problems from open situations. To explore and apply alternatives for its resolution, and to use approximate solutions when necessary.
- To identify and model complex systems. To perform analysis and qualitative approaches, establishing the uncertainty of the results. To pose hypotheses and validate them experimentally. To identify the major components and to establish commitments and priorities.

Learning outcomes.

At the end of the course, the students will have acquired advanced knowledge in:
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- characterizing signals as realizations of stochastic processes.
- estimation theory.
- time-frequency signal analysis.
- optimal filtering.
- adaptive Filtering.
- applying all above concepts to the development of signal processing subsystems for voice, audio, image, video and communication signals.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 52h</th>
<th>34.67%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours small group:</td>
<td>13h</td>
<td>8.67%</td>
</tr>
<tr>
<td>Self study:</td>
<td>85h</td>
<td>56.67%</td>
</tr>
</tbody>
</table>
### Content

#### Lecture 1. Introduction

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>11h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>4h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>1h</td>
</tr>
<tr>
<td>Self study:</td>
<td>6h 30m</td>
</tr>
</tbody>
</table>

**Description:**
- Notation of vector and random variables.
- Characterization of stochastic processes (stationary and ergodic), correlation matrix and its properties, power spectral density, and linear discrete processes and systems.

**Related activities:**
- Modeling AR processes.
- Identification of nonlinearities using the spectral coherence function.

#### Lesson 2. Detection

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>11h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>3h 30m</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>1h 30m</td>
</tr>
<tr>
<td>Self study:</td>
<td>6h 30m</td>
</tr>
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</table>

**Description:**
- The decision problem: hypothesis testing, terminology and examples.
- Decision criteria: MAP and Neyman-Pearson.
- Detection of deterministic signals and the Receiver Operating Characteristic (ROC) curve.

**Related activities:**
- Application to the detection of radar signals.

#### Lesson 3. Estimation Theory

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>30h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>8h</td>
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<tr>
<td>Guided activities:</td>
<td>5h</td>
</tr>
<tr>
<td>Self study:</td>
<td>17h</td>
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</table>

**Description:**
- Parameter estimation and MVUE estimator.
- Cramer-Rao limit and efficient estimator.
- Maximum Likelihood estimation, MAP estimation and MMSE estimation.

**Related activities:**
- CRLB in signal delay, frequency and angle of arrival estimation.
- ML estimation of channel, signal delay, frequency, power and SNR.
# Lesson 4. Optimum Filtering

**Learning time:** 25h  
Theory classes: 4h  
Guided activities: 4h  
Self study: 17h

**Description:**  
- Linear least mean square estimation.  
- Filtering problems: system identification, equalisation, cancelation, prediction and interpolation.  
- Wiener filter in the frequency domain.  
- Linear Regression and Least Squares design.

**Related activities:**  
- Interference cancellation, deconvolution and channel equalization, predicting processes over time.  
- Estimation of the channel impulse response.

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# Lesson 5. Adaptive filtering

**Learning time:** 20h 46m  
Theory classes: 5h  
Guided activities: 4h  
Self study: 11h 46m

**Description:**  
- Gradient method for linear regression.  
- Stochastic gradient methods. LMS algorithm.  
- LMS convergence and mismatch. Normalized LMS algorithm.

**Related activities:**  
- Active noise cancellation.  
- Hands-free telephone.  
- Adaptive differential coding (ADPCM).

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# Lesson 6. Spectral estimation

**Learning time:** 21h 55m  
Theory classes: 6h 30m  
Guided activities: 3h  
Self study: 12h 25m

**Description:**  
- Periodogram and tradeoff between bias and variance.  
- Filter banks and Capon estimator.  
- Detectors spectral lines.

**Related activities:**  
- Characterisation of biologic signals. Spectrum sensing.  
- Non-parametric spectral estimation. Detection of spectral lines.
### Lesson 7. Process representation and approximation

**Description:**
- Optimal transformation under the L2 sense.
- Unitary signal transformations: DFT and DCT.
- Wavelet transform.

**Related activities:**
- Image and audio coding. Bit allocation.

### Planning of activities

<table>
<thead>
<tr>
<th>Midterm exam</th>
<th>Hours: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 2h</td>
<td></td>
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</table>

**Description:**
Midterm exam

### (ENG) Proves de resposta llarga (Examen Final)

<table>
<thead>
<tr>
<th>Qualification system</th>
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Midterm and Final Exam.

The final mark will be computed as:

\[
\max(\text{Final_exam}, 0.6\cdot\text{Final_exam}+0.4\cdot\text{Midterm_exam})
\]

This course will assess the following generic skills:
- Self Learning (Middle Level)
- Ability to identify, formulate and solve engineering problems (Middle level)

### Regulations for carrying out activities

Neither notes nor any kind of electronic devices are allowed.
Bibliography

Basic:


Complementary:


Others resources:

1. Problems publication
2. Course slides