Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN AUDIOVISUAL SYSTEMS ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan

Learning objectives of the subject

To familiarize students with techniques and methods of probabilistic modelling through random variables and stochastic processes. Teach students to apply with sound judgement these techniques to solve practical problems that engineers have to face in their professional everyday activity, and for which a probabilistic-statistical type of model may give a more suitable practical solution than a deterministic model. Use appropriate software to find solutions to problems tackled over the course. Build on the specific and transversal competences associated with coursework, as described below.
### Study load

<table>
<thead>
<tr>
<th></th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time:</td>
<td>150h</td>
<td></td>
</tr>
<tr>
<td>Hours large group:</td>
<td>30h</td>
<td>20.00%</td>
</tr>
<tr>
<td>Hours medium group:</td>
<td>30h</td>
<td>20.00%</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
# Content

## TOPIC 1: Probability

<table>
<thead>
<tr>
<th>Description:</th>
<th>Specific objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1. The concept of probability. Axioms and properties.</td>
<td>- For students to:</td>
</tr>
<tr>
<td>1.2. Conditional probability. Independence.</td>
<td>- Describe the result of a random experiment in terms of the sample space and its subsets.</td>
</tr>
<tr>
<td>1.3. Total probability and Bayes theorems.</td>
<td>- Define the probability function.</td>
</tr>
<tr>
<td>Learning time: 15h</td>
<td>- Apply the properties of the probability function.</td>
</tr>
<tr>
<td>Theory classes: 3h</td>
<td>- Become familiar with conditional probability.</td>
</tr>
<tr>
<td>Practical classes: 3h</td>
<td>- Become familiar with independent events.</td>
</tr>
<tr>
<td>Self study: 9h</td>
<td>- Apply total probability and Bayes theorems properly.</td>
</tr>
</tbody>
</table>

## TOPIC 2: One-dimensional random variables

<table>
<thead>
<tr>
<th>Description:</th>
<th>Specific objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Discrete and continuous random variables. Probability distribution of a random variable.</td>
<td>- For students to:</td>
</tr>
<tr>
<td>2.2 Distribution function. Probability density function.</td>
<td>- Understand the basic characteristics of probability models and acquire a working knowledge of how they work.</td>
</tr>
<tr>
<td>2.3 Function of a random variable</td>
<td>- Interpret expectation and variance of a random variable.</td>
</tr>
<tr>
<td>2.4 Expectation, variance and standard deviation.</td>
<td>- Work with random variables.</td>
</tr>
<tr>
<td>2.5 Binomial geometric, negative binomial and Poisson distributions.</td>
<td>- Understand and work with models commonly used in engineering.</td>
</tr>
<tr>
<td>2.6 Exponential, uniform, normal and gamma distributions.</td>
<td>- Use adequate software for probability calculations and solving inverse problems with random variables.</td>
</tr>
<tr>
<td>2.7 Central limit theorem. Normal approximations.</td>
<td>- Understand and apply the normal approximation concept.</td>
</tr>
<tr>
<td>Learning time: 30h</td>
<td></td>
</tr>
</tbody>
</table>
## TOPIC 3: Multidimensional random variables

### Description:
- 3.1 Joint distribution of two variables.
- 3.2 Marginal distributions.
- 3.3 Conditional distributions. Independence of two random variables.
- 3.4 Distribution of a function of a random vector. Expected value of a function of two random variables.
- 3.5 Conditional expectation
- 3.6 Covariance. Correlation coefficient.
- 3.7 Operating with random variables: sum, product and quotient. Central limit theorem revisited
- 3.8 Bivariate normal distribution.
- 3.9 n dimensional random vectors. Multivariate normal distribution.

### Specific objectives:
- Understand the usual characteristics and parameters to study multidimensional random variables, particularly in the case of two random variables.
- Understand the concept of conditional expectation and independence in random variables.
- Understand how to operate with random variables.
- Apply matrix notation for dimension n random vectors.

### Learning time: 45h
- Theory classes: 9h
- Practical classes: 9h
- Self study: 27h

## TOPIC 4: Estimation

### Description:
- 4.1 Mean square estimation of a non observed random variable.
- 4.2 Parameter estimation on a random model.

### Specific objectives:
- Estimate the value of a variable not directly observable by observing an alternative variable.
- Know the usual estimators for expectation and variance, as well as the concept of efficient unbiased estimator.
- Find point estimators of a parameter through sample information.
- Understand the concept of confidence interval and how to use it to assess the estimation error.

### Learning time: 20h
- Theory classes: 4h
- Practical classes: 4h
- Self study: 12h
### TOPIC 5: Stochastic processes

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>5.1 Stochastic Processes. Definition, general characteristics and properties.</td>
</tr>
<tr>
<td>5.2 Strictly stationary process (SS) and wide sense stationary (WSS). Properties.</td>
</tr>
<tr>
<td>5.3 Wide sense stationary gaussian process.</td>
</tr>
<tr>
<td>5.4 Ergodicity in the mean and in the autocorrelation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
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</thead>
<tbody>
<tr>
<td>For students to:</td>
</tr>
<tr>
<td>- Understand the definition, characteristics and standard parameters for the study of stochastic processes.</td>
</tr>
<tr>
<td>- Understand the concepts of stationary, wide sense stationary and ergodic processes.</td>
</tr>
<tr>
<td>- Understand some of the mainly used stochastic processes models in telecommunication and audiovisual systems engineering.</td>
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<thead>
<tr>
<th>Learning time: 27h</th>
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<tbody>
<tr>
<td>Theory classes: 5h 30m</td>
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<tr>
<td>Practical classes: 5h 30m</td>
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<tr>
<td>Self study : 16h</td>
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### TOPIC 6: Elements for random signal analysis and processing

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>6.1 Power spectral density of a WSS process.</td>
</tr>
<tr>
<td>6.2 Wiener-Kinchine theorem.</td>
</tr>
<tr>
<td>6.3 Power spectral density properties for a WSS process</td>
</tr>
<tr>
<td>6.4 Cross spectra for wide sense stationary processes.</td>
</tr>
<tr>
<td>6.5 LTI systems with stochastic inputs</td>
</tr>
<tr>
<td>6.6 Response expectation for a WSS input to an LTI system.</td>
</tr>
<tr>
<td>6.7 Autocorrelation and power spectral density of the response to an LTI system with a WSS input.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
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</thead>
<tbody>
<tr>
<td>For students to:</td>
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<tr>
<td>- Understand the definition of power spectrum for a deterministic process and learn to establish analogies with deterministic processes.</td>
</tr>
<tr>
<td>- Understand linear processes and their application to random signal filtering.</td>
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<table>
<thead>
<tr>
<th>Learning time: 13h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 2h 30m</td>
</tr>
<tr>
<td>Practical classes: 2h 30m</td>
</tr>
<tr>
<td>Self study : 8h</td>
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</tbody>
</table>
### Planning of activities

<table>
<thead>
<tr>
<th>(ENG) AVALUACIÓ</th>
<th>Hours: 1h</th>
<th>Theory classes: 1h</th>
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<table>
<thead>
<tr>
<th>(ENG) TREBALL ASSISTIT PER ORDEINADOR</th>
<th>Hours: 1h</th>
<th>Theory classes: 1h</th>
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</table>

**Description:**
Over the course of the semester the student will be asked to make use of appropriate software, in order to better assimilate certain concepts and solve certain exercises.

### Qualification system

The final mark \( N_f \) will be obtained by weighted aggregation of marks given for assessment items A1, A2, A3, and A4, with weights 10%, 30%, 20%, and 40%, respectively, through the following formula:

\[
N_f = \max \{0.10 \cdot a_1 + 0.3 \cdot a_2 + 0.4 \cdot a_2, 0.20 \cdot a_3 \cdot 0.4 \cdot a_4, 0.6 \cdot a_4\}
\]

where \( a_i \) is the mark in \( A_i \).

This allows overcoming unsatisfactory marks in A1 and A3 through accumulating the weight of A1 in A2, and the weight of A3 in A4, when needed.

In addition, students who, after assessment item A2, have \( 0 < \max \{0.10 \cdot a_1 + 0.3 \cdot a_2, 0.4 \cdot a_2\} < 2 \) may overcome unsatisfactory marks in A1 and A2 by taking an additional exam R just after A4.

The corrected final mark \( N_f(R) \), for students taking exam R, and getting mark r, will be:

\[
N_f(R) = \max\{\max\{0.10 \cdot a_1 + 0.3 \cdot a_2, 0.4 \cdot a_2\}, 0.4 \cdot r\} + \max\{0.20 \cdot a_3 + 0.4 \cdot a_4, 0.6 \cdot a_4\}
\]

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.

If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

### Regulations for carrying out activities

The evaluation consists in face-to-face assessment acts. When not done they will be qualified with zero.
Bibliography

Basic:


Complementary:


Others resources:

List of proposed problems. Available Atena.

Collection of problems solved by each subject of the course. Available Athena
List of proposed problems. Available Athena.