Course guides
230622 - DSAP - Digital Speech and Audio Processing

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.
Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).
Academic year: 2020 ECTS Credits: 5.0 Languages: English

LECTURER
Coordinating lecturer: Climent Nadeu
Others:

PRIOR SKILLS
Advanced knowledge of Signals, Systems, and Transforms
Basic knowledge of Probability, Random variables and Stochastic processes
Experience with Matlab programming
Recommended:
- Basic knowledge of Machine Learning
- Python language

REQUIREMENTS
Two courses of the area Signals, Systems, and Transforms
At least one course about Probability, Random variables and Stochastic processes

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.

Transversal:
2. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

3. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

4. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
TEACHING METHODOLOGY

- Lectures (50%)
- Application classes (with Matlab or similar) (50%)
- Team work: course project, application classes
- Individual work: preparation and completion (out classroom) of application activities

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject
Understanding and being competent on a relevant set of concepts and techniques in the field of digital audio processing, and their application to problems arising from real applications. Signals and applications related to speech and music will be particularly considered.

Learning results:
Ability to digitally process audio signals, in an application-oriented context, in order to analyze, model, extract information, clean, modify, and generate/synthesize them.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>39.0</td>
<td>31.20</td>
</tr>
<tr>
<td>Self study</td>
<td>86.0</td>
<td>68.80</td>
</tr>
</tbody>
</table>

Total learning time: 125 h

CONTENTS

Introduction
Description:
Course presentation
Audio diversity
Characteristics of speech and music. Production model
Hearing and auditory modeling
Short-time Fourier transform (STFT) and spectrogram
The short-time Fourier transform

Full-or-part-time: 12h
Theory classes: 6h
Self study : 6h

Modeling and representation of audio signals
Description:
Production-based all-pole modeling
Pitch determination for speech and music
LPC-based coding used in mobile telephony

Full-or-part-time: 12h
Theory classes: 6h
Self study : 6h
### Enhancement of voice and audio signals

**Description:**
- Denoising: spectral subtraction, Wiener-based filtering, neural nets
- Blind source separation: ICA, NMF
- Cancellation: echo, interference

**Full-or-part-time:** 12h  
Theory classes: 6h  
Self study: 6h

### Recognition and detection of audio and speech

**Description:**
- Pattern-matching dynamic approaches.  
- Statistical and deep learning approaches  
- Audio activity detection  
- Application to speech and sound recognition

**Full-or-part-time:** 12h  
Theory classes: 6h  
Self study: 6h

### Multi-microphone audio processing

**Description:**
- Room acoustics  
- Array beamforming  
- Acoustic source localization and tracking

**Specific objectives:**

**Full-or-part-time:** 12h  
Theory classes: 6h  
Self study: 6h

### Analysis and synthesis of audio signals

**Description:**
- Short-term analysis-synthesis of (quasi)periodic signals. Time-scale and pitch modification  
- Spatial audio synthesis with HRTF functions

**Full-or-part-time:** 12h  
Theory classes: 6h  
Self study: 6h
**Project realization and presentation**

**Description:**
Design, implementation and test of a audio processing system for a specific application
Oral presentation of 1) project proposal, 2) critical review, and 3) project realization and conclusions
Written report, conference paper style

**Full-or-part-time:** 55h
Theory classes: 4h
Self study: 51h

**ACTIVITIES**

**Practical exercises with Matlab or similar, about 50% of classroom time**

**Description:**
Most weeks the students work for almost 2 hours with a Matlab file and data provided by the teacher. They also do some complementary work at home.

**Material:**
Theory slides, Matlab code, data (signals, etc)

**Delivery:**
Learning of topics is assessed with bi-weekly questionnaires

**Full-or-part-time:** 20h
Theory classes: 20h

**Short tests at the end of each topic**

**Full-or-part-time:** 1h
Theory classes: 1h

**Course project**

**Description:**
Team project realization, which includes audio processing experimental work, and is presented both orally and in writing.

**Full-or-part-time:** 60h
Theory classes: 60h

**Oral presentations**

**Description:**
Oral presentation of the course project in three times: proposal, review, and final presentation.

**Full-or-part-time:** 0h 40m
Theory classes: 0h 40m
**GRADING SYSTEM**

Attendance/participation in class (10%)
Short tests every two weeks (30%)
Course project (60%)

**BIBLIOGRAPHY**

**Basic:**

**Complementary:**

**RESOURCES**

**Audiovisual material:**
- Slides. Slides used in lectures

**Computer material:**
- Codi programes. Software codes in Matlab or similar

**Other resources:**
Lecture slides
Practical work statements and programs