230622 - DSAP - Digital Speech and Audio Processing

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019).
           (Teaching unit Optional)
MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
MASTER'S DEGREE IN INFORMATION AND COMMUNICATION TECHNOLOGIES (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 5  Teaching languages: English

Teaching staff
Coordinator: Climent Nadeu

Opening hours
Timetable: Tuesday and Thursday from 10:00 to 13:00

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.
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>Total learning time: 125h</th>
<th>Hours large group: 39h</th>
<th>% 31.20%</th>
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<tbody>
<tr>
<td>Hours large group: 39h</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td>Hours medium group:</td>
<td>0h</td>
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<tr>
<td>Hours small group:</td>
<td>0h</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td>Self study:</td>
<td>86h</td>
<td>68.80%</td>
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## Course Content

### Introduction

**Learning time:** 12h  
**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

### Modeling and representation of audio signals

**Learning time:** 12h  
**Description:**  
Production-based all-pole modeling  
Pitch determination for speech and music  
LPC-based coding used in mobile telephony

### Enhancement of voice and audio signals

**Learning time:** 12h  
**Description:**  
Denoising: spectral subtraction, Wiener-based filtering, neural nets  
Blind source separation: ICA, NMF  
Cancellation: echo, interference
### Recognition and detection of audio and speech

**Learning time:** 12h  
Theory classes: 6h  
Self study: 6h

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

### Multi-microphone audio processing

**Learning time:** 12h  
Theory classes: 6h  
Self study: 6h

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

**Specific objectives:**

### Analysis and synthesis of audio signals

**Learning time:** 12h  
Theory classes: 6h  
Self study: 6h

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

**Learning time:** 55h
- Theory classes: 4h
- Self study: 51h

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## Planning of activities

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

**Hours:** 20h
- Theory classes: 20h

**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.

**Support materials:**
- Theory slides
- Matlab code
- Data (signals, etc.)

**Descriptions of the assignments due and their relation to the assessment:**
Learning of topics is assessed with bi-weekly questionnaires

### Short tests at the end of each topic

**Hours:** 1h
- Theory classes: 1h

### Course project

**Hours:** 60h
- Theory classes: 60h

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

### Oral presentations

**Hours:** 0h 40m
- Theory classes: 0h 40m

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

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

Bibliography

Basic:


Complementary:


Others resources:
Lecture slides 
Practical work statements and programs

Audiovisual material

Slides 
Slides used in lectures

Computer material

Codi programes 
Software codes in Matlab or similar