230375 - GSP - Graph Signal 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 TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Teaching unit Optional)
ECTS credits: 3
Teaching languages: English

Teaching staff
Coordinator: Alba Pagès Zamora
Others: Alba Pagès Zamora

Prior skills
Basic knowledge of matrix analysis, Fourier transform, and signal filtering.
Basic knowledge of programming in Matlab.

Degree competences to which the subject contributes
Specific:
CE1. 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:
CT4. 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.
CT5. 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
- Theoretical lectures.
- Practical sessions in Matlab, and presentation of proposed problems.
- Preparation and presentation of a final project.

Learning objectives of the subject
Graphs are useful for representing data obtained in numerous applications such as, for example, traffic evolution in a transport network, temperature values in different geographic locations, information dissemination in social networks or functional activities in the brain. The representation, analysis and compression of such data is a challenging task and requires the development of new tools that can identify and adequately exploit the structure of the data.
In this course, students will become familiar with the framework of "Graph Signal Processing", a discipline useful for processing data lying on a graph and that extends basic concepts of signal processing to graphs, such as frequency domain and filtering. Hand-out sessions will provide students with practical skills in the analysis of data in graphs.
### Study load

<table>
<thead>
<tr>
<th>Total learning time: 75h</th>
<th>Hours large group:</th>
<th>16h</th>
<th>21.33%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours small group:</td>
<td>8h</td>
<td>10.67%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>51h</td>
<td>68.00%</td>
</tr>
<tr>
<td>Content</td>
<td>Learning time:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Introduction</strong></td>
<td>2h</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Graph Theory</strong></td>
<td>9h 30m</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Graph Signals</strong></td>
<td>9h</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Graph Systems and Filtering of Graph Signals</strong></td>
<td>11h 30m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Description:**
- Course organization. Motivation and main applications of graph signals.
- Graph Definition. Laplacian matrix and spectral properties.
- Definition of graph signals. Graph Fourier Transform. Convolution of two graph signals.
- Graph linear systems and graph filters. Examples of graph filters: Shift Operator and Polynomial graph filters.

**Related activities:**
- Practical session: spectral clustering
- Practical session: Frequency domain in graphs.
- Practical session: denoising in graph signals.
### Applications of graph signal processing

<table>
<thead>
<tr>
<th><strong>Learning time:</strong> 15h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 3h</td>
</tr>
<tr>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>

**Description:**
Random processes in graphs. Graph sampling. Topology learning.

**Related activities:**
Practical session: topology learning.

### Final Project

<table>
<thead>
<tr>
<th><strong>Learning time:</strong> 28h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td>Practical classes: 3h</td>
</tr>
<tr>
<td>Self study: 21h</td>
</tr>
</tbody>
</table>

**Description:**
Personal work of one application.

**Related activities:**
Guided practical session. Presentation of project results.

### Qualification system

- Attendance is mandatory.
- Participation in class (20%).
- Problems and/or group or individual presentation (80%).

### Regulations for carrying out activities

There is no final exam.

### Bibliography

**Others resources:**
- Lecture slides.
- Matlab graph toolbox and practical session guide.