Course guides
230375 - GSP - Graph Signal 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: 2021  ECTS Credits: 3.0  Languages: English

LECTURER
Coordinating lecturer: 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 individual sessions in Matlab, and presentation of proposed problems.
- Practical sessions in groups and presentation of a report.

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>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>16.0</td>
<td>21.33</td>
</tr>
<tr>
<td>Self study</td>
<td>51.0</td>
<td>68.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>8.0</td>
<td>10.67</td>
</tr>
</tbody>
</table>

Total learning time: 75 h

**CONTENTS**

### Introduction

**Description:**
Course organization. Motivation and applications of graph signals.

**Full-or-part-time: 1h 30m**
- Theory classes: 0h 30m
- Self study: 1h

### Algebraic Graph Theory

**Description:**
Graph theory fundamentals. Laplacian matrix and spectral properties.

**Related activities:**
- Application: Random Walks on Graphs and Spectral Clustering
- Practical Session: Spectral Clustering

**Full-or-part-time: 14h**
- Theory classes: 5h
- Practical classes: 3h
- Self study: 6h

### Graph Signals

**Description:**
Definition of graph signals. Graph Fourier Transform. Convolution of graph signals.

**Related activities:**
- Application: "Average Consensus"
- Practical session: Frequency domain in graphs.

**Full-or-part-time: 6h 30m**
- Theory classes: 2h 30m
- Practical classes: 1h
- Self study: 3h
Graph topology learning

Description:
Graphs based on similarity of node attributes. Graph learning based on signals

Full-or-part-time: 4h 30m
Theory classes: 2h 30m
Self study: 2h

Graph Systems and Filtering of Graph Signals

Description:
Graph linear systems filters. Graph filters in the frequency domain. Examples of graph filters.

Related activities:
Application: Denoising of graph signals and translation of signals across a graph.
Practical session: filtering of graph signals.

Full-or-part-time: 8h 30m
Theory classes: 4h 30m
Practical classes: 1h
Self study: 3h

Graph Convolutional Neural Networks

Description:
Multilayer Graph Convolutional Neural Networks with multiple features.

Full-or-part-time: 7h
Theory classes: 4h
Self study: 3h

GRADING SYSTEM

- Attendance is mandatory.
- Participation in class.
- Problems and/or group or individual presentation.

EXAMINATION RULES.

There is no final exam.

RESOURCES

Other resources:
Lecture slides.
Matlab graph toolbox and practical session guides.