Course guide

270225 - POE - Spoken and Written Language Processing

Unit in charge: Barcelona School of Informatics
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.
Degree: BACHELOR’S DEGREE IN DATA SCIENCE AND ENGINEERING (Syllabus 2017). (Compulsory subject).
Academic year: 2022 ECTS Credits: 6.0 Languages: Spanish, English

LECTURER

Coordinating lecturer: FRANCISCO JAVIER HERNANDO PERICAS
Others: Segon quadrimestre:
CARLOS ESCOLANO PEINADO - 11, 12
FRANCISCO JAVIER HERNANDO PERICAS - 11, 12

PRIOR SKILLS

College Calculus, Linear Algebra
Basic Probability and Statistics
Large programming experience in Pyhton
Machine Learning.
Introduction to Deep Learning

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE5. Design and apply techniques of signal processing, choosing between different technological tools, including those of Artificial vision, speech recognition and multimedia data processing.
CE6. Build or use systems of processing and comprehension of written language, integrating it into other systems driven by the data. Design systems for searching textual or hypertextual information and analysis of social networks.

General:
CG1. To design computer systems that integrate data of provenances and very diverse forms, create with them mathematical models, reason on these models and act accordingly, learning from experience.
CG2. Choose and apply the most appropriate methods and techniques to a problem defined by data that represents a challenge for its volume, speed, variety or heterogeneity, including computer, mathematical, statistical and signal processing methods.
CG4. Identify opportunities for innovative data-driven applications in evolving technological environments.
CG5. To be able to draw on fundamental knowledge and sound work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

Transversal:
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.
CT6. Autonomous Learning. Detect deficiencies in one’s own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.
CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.

Basic:
CB4. That the students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.
CBS. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy.
TEACHING METHODOLOGY

Lectures presenting new theoretical material and practical examples.
Theoretical and practical assignments grouped in subjects.
Research project, presented in written and oral form by the students.

LEARNING OBJECTIVES OF THE SUBJECT

1. Know the most important deep learning technologies of interest in the processing of oral and written language.
2. The student must know the most important applications of speech and language technology.
3. The student must be able to select the most appropriate speech and language technology for a particular task or application.
4. Develop innovative applications that use speech technology appropriately.
5. El alumno debe ser capaz de identificar los parámetros fundamentales de la voz en el dominio temporal y frecuencial.
6. The student must know the most important mathematical and machine learning tools for the analysis of the voice as vector quantification (VQ), Gaussian mixture models (GMM) and hidden Markov models (HMM).
7. The student must know the techniques for statistical language modeling.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Self study</td>
<td>90,0</td>
<td>60.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>45,0</td>
<td>30.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>15,0</td>
<td>10.00</td>
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</tbody>
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Total learning time: 150 h

CONTENTS

Introduction to language and speech technologies and applications

Description:
Applications of oral and written language processing. Social impact.
Main blocks of a natural language processing system: speech recognition, natural language processing, text to speech conversion.
Language as a sequence of words. Vector representation of words. One-hot encoding versus continuous-space representations.
Word2vec: Continuous bag-of-words (CBOW) versus Continuous skip-gram. GloVe vectors. Structures and analogies in word vector representations.

Language Modeling

Description:
Statistical modeling based on N-grams.

Contextual language representations

Description:
General purpose language representations.
Unsupervised training. Unidirectional and bidirectional systems.
Main architectures: ULMfit, OpenAI GPT, ELMo, BERT, XLM. Applications.
<table>
<thead>
<tr>
<th>Neural Machine Translation</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Introduction to Machine Translation. Automatic quality evaluation: BLEU</td>
</tr>
<tr>
<td>Neural Machine Translation.</td>
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</table>

<table>
<thead>
<tr>
<th>Introduction to automatic speech recognition</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Pattern matching. Dynamic time warping.</td>
</tr>
<tr>
<td>Hidden Markov models. Isolated word recognition.</td>
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<tr>
<td>Large vocabulary continuous ASR: Acoustic modeling, Language modeling, Search.</td>
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<tr>
<th>Speech synthesis</th>
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<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Linguistic processing.</td>
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<tr>
<td>Prosody modeling.</td>
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<tr>
<td>Waveform generation.</td>
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<tr>
<td>Concatenation methods.</td>
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</tbody>
</table>
### Topic development: Introduction to speech and language technology and applications

**Description:**
Introduction to speech and language technology and applications.

**Word vectors**

**Specific objectives:**
2, 3

**Related competencies:**
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- CG5. To be able to draw on fundamental knowledge and sound work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
- CG2. Choose and apply the most appropriate methods and techniques to a problem defined by data that represents a challenge for its volume, speed, variety or heterogeneity, including computer, mathematical, statistical and signal processing methods.
- CG1. To design computer systems that integrate data of provenances and very diverse forms, create with them mathematical models, reason on these models and act accordingly, learning from experience.
- CE6. Build or use systems of processing and comprehension of written language, integrating it into other systems driven by the data. Design systems for searching textual or hypertextual information and analysis of social networks.
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- CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.
- CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
- CB4. That the students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.

**Full-or-part-time:** 18h
- Theory classes: 6h
- Laboratory classes: 2h
- Self study: 10h
Topic development: Language Modeling

Specific objectives:

6

Related competencies:

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Full-or-part-time: 18h
Theory classes: 6h
Laboratory classes: 2h
Self study: 10h
**Topic development: Automatic Speech Recognition**

**Description:**
Automatic Speech Recognition

**Specific objectives:**
5, 6, 7

**Related competencies:**
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**Full-or-part-time:** 20h

Theory classes: 9h
Guided activities: 1h
Self study: 10h
Topic development: Speech Synthesis

Description:
Speech Synthesis

Specific objectives:
2

Related competencies:
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Full-or-part-time: 16h
Theory classes: 6h
Self study: 10h
**Topic development: Contextual language representations**

**Specific objectives:**

1.  

**Related competencies:**

- **CG4.** Identify opportunities for innovative data-driven applications in evolving technological environments.
- **CG5.** To be able to draw on fundamental knowledge and sound work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
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**Full-or-part-time:** 28h

- Theory classes: 9h
- Laboratory classes: 2h
- Guided activities: 1h
- Self study: 16h

**Topic development: Neuronal Machine Translation**

**Description:**

Neuronal Machine Translation

**Full-or-part-time:** 18h

- Theory classes: 6h
- Laboratory classes: 2h
- Self study: 10h
Final project

Description:
Final project

Specific objectives:
3, 4

Related competencies:
CG4. Identify opportunities for innovative data-driven applications in evolving technological environments.
CG5. To be able to draw on fundamental knowledge and sound work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
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Full-or-part-time: 38h
Theory classes: 3h
Laboratory classes: 7h
Guided activities: 4h
Self study: 24h

GRADING SYSTEM

Course evaluation is based on the following aspects:

- Two exams, a midterm exam and the final exam, to assess the knowledge acquired but the student on the topics worked on in theory and practice sessions (40%)
- Explanation/rubrique of a research paper (10%)
- Evaluation of laboratory assignments: (36%)
- Evaluation of the final lab project (14%)

BIBLIOGRAPHY

Basic:
Complementary: