ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000819 - Acoustic signal processing

DEGREE PROGRAMME

09AQ - Master Universitario en Ingenieria de Telecomunicacion

ACADEMIC YEAR & SEMESTER

2017/18 - Semester 2

Index

Learning guide

1. Description

1.1. Subjet details

Name of the subject	93000819 - Acoustic signal processing
No of credits	6 ECTS
Type	Optional
Academic year ot the programme	Second year
Semester of tuition	Semester 4
Tuition period	February-June
Tuition languages	English
Degree programme	09AQ - Master Universitario en Ingenieria de Telecomunicacion
Centre	Escuela Tecnica Superior de Ingenieros de Telecomunicacion
Academic year	2017-18

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Luis Alfonso Hernandez Gomez (Subject coordinator)	C-330	luisalfonso.hernandez@upm.es	Sin horario.
Eduardo Lopez Gonzalo	C-330	eduardo.lopez@upm.es	Sin horario.

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Analisis de señal para comunicaciones

3.2. Other recommended learning outcomes

- Signal Processing, Speech and Audio Processing

- Previous exposure to a programming language, such as MATLAB, R or Python

4. Skills and learning outcomes *

4.1. Skills to be learned

CE1 - Capacidad para aplicar métodos de la teoría de la información, la modulación adaptativa y codificación de canal, así como técnicas avanzadas de procesado digital de señal a los sistemas de comunicaciones y audiovisuales.

CE15 - Capacidad para la integración de tecnologías y sistemas propios de la Ingeniería de Telecomunicación, con carácter generalista, y en contextos más amplios y multidisciplinares como por ejemplo en bioingeniería, conversión fotovoltaica, nanotecnología, telemedicina.

CG1 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación.

CG2 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.

CG4 - Que los estudiantes sepan comunicar sus conclusiones ?y los conocimientos y razones últimas que las sustentan? a públicos especializados y no especializados de un modo claro y sin ambigüedades.

CG5 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CT1 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa.

CT3 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas.

CT4 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo.

CT5 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente.

4.2. Learning outcomes

RA295 - Competence on technologies for extracting knowledge from a variety of acoustic signals combining signal processing and machine learning

RA10 - Saber realizar una presentación de carácter técnico, ante una audiencia de pares, que describa el trabajo realizado y sus resultados, de forma clara y bien estructurada, en el tiempo establecido, y usando un lenguaje preciso

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This course will present state-of-the-art technologies for processing, extracting knowledge and generating acoustic signals. The course will consider a broad range of applications: speech, music, audio, environmental acoustics, forensics acoustics, biomedical applications, bots and human-machine interaction, speech-to-speech translation, assistive technologies etc.

Together with the basic concepts of different acoustic fields mayor emphasis in the course will be put on the combination of signal processing and machine learning, particularly deep neural networks, for generating audio signals (speech and music) and extracting relevant knowledge from them (recognition of speech, speaker,

language, emotions, musical genre, acoustic events etc.). Most of the activities in the course will be practical using latest technologies such Google Tensorflow for machine learning and deep learning applied on acoustic signals.

5.2. Syllabus

1. Fundamentals of Acoustics
   1.1. Reviewing basic concepts of sounds and the acoustic environment
   1.2. Overview of application fields: speech, music, audio, environmental acoustics, forensics acoustics, biomedical applications, bots and human-machine interaction, speech-to-speech translation, assistive technologies, etc.
2. Acoustic Signals and Systems
   2.1. Acoustic sources: signals characterization
   2.2. Time-frequency analysis
   2.3. Time-space analysis
   2.4. Physical and parametric acoustic models
3. Processing and extracting knowledge from acoustics
   3.1. Reviewing traditional feature extraction technique for acoustic signals
   3.2. Machine learning approaches in acoustics
4. Reviewing Machine learning
   4.1. Basic machine learning algorithms
   4.2. Introduction to machine learning Tools
5. Deep Neural Networks in acoustics
   5.1. Overview of applications and challenges of Deep Neural Networks in acoustics
   5.2. Practical Introduction to Deep Neural Networks using Tensorflow
   5.3. Application projects
      5.3.1. Modeling and extracting acoustic features using Feed Forward and Convolutional Networks
      5.3.2. Recurrent Networks for modeling acoustic dynamics: LSTM, Bi-directional LSTM, GRU, etc.
      5.3.3. Extracting knowledge: speech, speaker, language, musical genre, etc
      5.3.4. Audio synthesis: text-to-speech, music, audio effects, de-noising, sound source separation, ..
      5.3.5. Interactive systems: bots, human-machine interaction, assistive technology, hearing aids

5.3.6. Advanced topics: Transfer Learning, Generative Adversarial Network, Reinforcement Learning

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	**Fundamentals of acoustics** Duration: 04:00 Lecture			
2	**Acoustics Signals & Systems** Duration: 04:00 Lecture			
3		**Acoustics Signals & Systems** Duration: 04:00 Laboratory assignments		
4	**Processing and extracting knowledge from acoustics** Duration: 02:00 Lecture	**Processing and extracting knowledge from acoustics** Duration: 02:00 Laboratory assignments		
5	**Reviewing Machine learning** Duration: 02:00 Lecture	**Reviewing Machine learning** Duration: 02:00 Laboratory assignments		
6	**Deep Learning in Acoustics** Duration: 02:00 Lecture	**Introduction to Deep Learning using Tensorflow** Duration: 02:00 Laboratory assignments		
7		**Introduction to Deep Learning using Tensorflow** Duration: 04:00 Laboratory assignments		
8		**Introduction to Deep Learning using Tensorflow** Duration: 04:00 Laboratory assignments		
9		**Introduction to Deep Learning using Tensorflow** Duration: 04:00 Laboratory assignments		
10		**Introduction to Deep Learning using Tensorflow** Duration: 02:00 Laboratory assignments		**Evaluation: practical use of Deep Learning on acoustic signals** Individual presentation Continuous assessment and final examination Duration: 01:00
11		**Application projects** Duration: 04:00 Laboratory assignments		

12		**Application projects** Duration: 04:00 Laboratory assignments		
13		**Application projects** Duration: 04:00 Laboratory assignments		
14		**Application projects** Duration: 04:00 Laboratory assignments		
15				
16				
17				**Final project evaluation** Individual presentation Continuous assessment and final examination Duration: 01:00

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Evaluation: practical use of Deep Learning on acoustic signals	Individual presentation	Face-to-face	01:00	35%	3.5 / 10	CE1 CE15 CG1 CG2 CG4 CT1 CT4 CT5
17	Final project evaluation	Individual presentation	Face-to-face	01:00	65%	3.6 / 10	CE15 CE1 CG1 CG2 CG5 CG4 CT1 CT3 CT4

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Evaluation: practical use of Deep Learning on acoustic signals	Individual presentation	Face-to-face	01:00	35%	3.5 / 10	CE1 CE15 CG1 CG2 CG4 CT1 CT4 CT5
17	Final project evaluation	Individual presentation	Face-to-face	01:00	65%	3.6 / 10	CE15 CE1 CG1 CG2 CG5 CG4 CT1 CT3 CT4

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Evaluation: practical use of Deep Learning on acoustic signals	Individual presentation	Face-to-face	01:00	35%	3.5 / 10	CE1 CE15 CG1 CG2 CG4 CT1 CT4 CT5
Final project evaluation	Individual presentation	Face-to-face	01:00	65%	3.5 / 10	CE1 CE15 CG1 CG2 CG5 CG4 CT1 CT3 CT4

7.2. Assessment criteria

Students will be qualified through continuous evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students willing to renounce to continuous evaluation must notify in writing, through the Register of the School, to the coordinator before starting the 7th week of the semester.

Evaluation will assess if students have acquired all the competences of the subject. Thus, evaluation through final assessment will be carried out considering all the evaluation techniques used in continuous evaluation (EX, ET, TG, etc.), and will be celebrated in the exam period approved by Junta de Escuela for the current academic semester and year. Evaluation activities that assess learning outcomes that cannot be evaluated through a single exam can be carried out along the semester.

Extraordinary examination will be carried out exclusively by the final assessment method.

In all the cases, continuous evaluation, final assessment or extraordinary examination, course will be assessed

using individual presentations to demonstrate students' abilities to apply Deep Learning on acoustic signals (this will represent 35% of final grade). A final collaborative project will be developed to assess both individual achievements and the development of teamwork skills, as this is one of the learning objectives for the course (final project assessment will represent 65% of the final grade).

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Handbook of signal processing in acoustics	Bibliography	Havelock, David, Sonoko Kuwano, and Michael Vorländer, eds. Handbook of signal processing in acoustics. Springer Science & Business Media, 2008.
Tensorflow Intro	Web resource	https://www.tensorflow.org/get_started/
Simple Audio Recognition	Web resource	https://www.tensorflow.org/versions/master/tutorials/audio_recognition
Music and Art Using Machine Learning	Web resource	https://magenta.tensorflow.org/
Audio Analysis in Python	Web resource	https://github.com/tyiannak/pyAudioAnalysis/wiki
Intro Machine Learning Python	Web resource	https://www.dataquest.io/blog/machine-learning-python/
Introduction to Statistical Learning	Bibliography	James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013.