ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000946 - Big Data For Image And Video Signals

DEGREE PROGRAMME

09AT - Master Universitario en Teoria de la Señal y Comunicaciones

ACADEMIC YEAR & SEMESTER

2019/20 - Semester 2

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Learning guide

1. Description

1.1. Subject details

Name of the subject	93000946 - Big Data For Image And Video Signals
No of credits	4 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	09AT - Master Universitario en Teoria de la Señal y Comunicaciones
Centre	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
Academic year	2019-20

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Narciso Garcia Santos	C-324	narciso.garcia@upm.es	Sin horario. Appointment arranged by email
Carlos Roberto Del Blanco Adan (Subject coordinator)	C-306	carlosrob.delblanco@upm.es	Sin horario. Appointment arranged by email

Luis Salgado Alvarez De Sotomayor	C-325	luis.salgado@upm.es	Sin horario. Appointment arranged by email

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

2.2. Research assistants

Name and surname	Email	Faculty member in charge
Berjon Diez, Daniel	daniel.berjon@upm.es	Moran Burgos, Francisco
Diaz Martin, Cesar	cesar.diazm@upm.es	Garcia Santos, Narciso

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Python programming

- Linear algebra

- Basic probability

- Image Processing and Computer Vision fundamentals

- MATLAB programming

- Basic optimization

- Basic Machine Learning

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - 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

CB07 - 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

CB09 - 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

CB10 - 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

CE01 - Analizar y aplicar técnicas para el diseño y desarrollo avanzado de equipos y sistemas, basándose en la teoría de la señal y las comunicaciones, en un entorno internacional

CE03 - Valorar y contrastar la utilización de las diferentes técnicas disponibles para la resolución de problemas reales dentro del área de teoría de la señal y comunicaciones.

CT01 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa

CT03 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas

CT04 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo

CT05 - 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

RA1 - Capacidad para desarrollar técnicas de tratamiento de señal específicas para datos masivos y diseñar aplicaciones sobre señales como: imágenes, señales de video, voz, audio y las procedentes de sensores de diversanaturaleza

RA34 - Capability to develop and evaluate machine-learning techniques and to design big data learning systems

RA7 - Capacidad para desarrollar y evaluar técnicas de aprendizaje automático y diseñar sistemas de aprendizaje para datos masivos

RA32 - Capability for planning, design and implement applications, incorporating signal processing, statistical analysis and machine learning

RA2 - Capacidad para planificar, diseñar y realizar aplicaciones que integren técnicas de tratamiento de señal, análisis estadístico y aprendizaje automático sobre datos masivos.

* 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 presents a selection of the most recent and relevant techniques for massively processing images and video. After the introduction of the course goals in the first lesson, the theory of Compressive Sensing is introduced in the second lesson. This is a recent framework for the analysis and reconstructions of massive data that overcomes some challenges related to memory restrictions, computational cost, and the so called "curse of dimensionality". Next, Compressive Sensing framework is applied for the massive processing of image and video signals in the third lesson, and for the efficient sampling of data (it can be significantly more efficient than the famous Shannon-Nyquist sampling theorem under certain assumptions) in the fourth lesson. Next, the fundamental concept of sparsity of the Compressive Sensing framework is used to build efficient sparse representations and dictionaries, which will be applied for the task of object detection and recognition. In the sixth lesson, the Random Projection framework will be introduced, which is focused on the analysis and dimensionality reduction of massive data. The main difference of Random Projections with Compressive Sensing is that the signal reconstruction is unnecessary, relaxing the conditions for applying the Random Projection framework. Lastly, the seventh lesson will present case studies about the practical applications of the Random Projection framework to the field of computer vision and image processing.

5.2. Syllabus

1. Introduction
2. Compressive sensing
3. Compressive sensing for image and video
4. Data acquisition. New sampling perspectives
5. Object detection/recognition: sparse representation and dictionaries
6. Dimensionality reduction: random projections
7. Random projections applied to computer vision applications

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	**Introduction** Duration: 03:00 Lecture			
2	**Introduction** Duration: 02:00 Lecture **Compressive Sensing** Duration: 01:00 Lecture			
3	**Compressive Sensing** Duration: 03:00 Lecture			
4	**Compressive Sensing** Duration: 03:00 Lecture			
5	**Compressive sensing for image and video** Duration: 01:00 Lecture	**Laboratory session: Compressive sensing** Duration: 02:00 Laboratory assignments		
6		**Laboratory session: Compressive sensing for image and video** Duration: 03:00 Laboratory assignments		
7	**Data acquisition. New sampling perspectives** Duration: 02:00 Lecture	**Laboratory session: Compressive sensing for image and video** Duration: 01:00 Laboratory assignments		
8		**Laboratory session: Data acquisition** Duration: 02:10 Laboratory assignments		**Exam (theory+lab): Compressive sensing and Compressive sensing for image and video** Problem-solving test Continuous assessment Duration: 00:50
9	**Object detection/recognition: sparse representation and dictionaries** Duration: 03:00 Lecture			
10	**Dimensionality reduction: random projections** Duration: 01:00 Lecture	**Laboratory session: Object detection/recognition** Duration: 02:00 Laboratory assignments		

11	**Dimensionality reduction: random projections** Duration: 02:10 Lecture			**Exam (theory+lab): Data acquisition and Object detection/recognition** Problem-solving test Continuous assessment Duration: 00:50
12		**Laboratory session: random projections** Duration: 03:00 Laboratory assignments		
13	**Random projections applied to vision applications** Duration: 02:00 Lecture	**Laboratory session: Random projections applied to vision applications** Duration: 01:00 Laboratory assignments		
14		**Laboratory session: Random projections applied to vision applications** Duration: 02:10 Laboratory assignments		**Exam (theory+lab): Random projections and Random projections applied to vision applications** Problem-solving test Continuous assessment Duration: 00:50
15				
16				
17				**Final exam for one final examination** Written test Final examination Duration: 03:00

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
8	Exam (theory+lab): Compressive sensing and Compressive sensing for image and video	Problem-solving test	Face-to-face	00:50	35%	/ 10	CB09 CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10
11	Exam (theory+lab): Data acquisition and Object detection/recognition	Problem-solving test	Face-to-face	00:50	30%	/ 10	CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10 CB09 CT01
14	Exam (theory+lab): Random projections and Random projections applied to vision applications	Problem-solving test	Face-to-face	00:50	35%	/ 10	CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB09 CT01 CB10

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills

17	Final exam for one final examination	Written test	Face-to-face	03:00	100%	5 / 10	CB09 CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Extraordinary assessment exam	Written test	Face-to-face	03:00	100%	5 / 10	CB09 CT01 CB07 CT03 CB06 CT04 CE01 CT05 CB10

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 complete the Moodle task entitled "Renounce to continuous evaluation" before 20 days since the course has started (deadline will be announced in Moodle).
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.

The final grade will depend of the chosen assessment policy by the student. In any case, the passing mark for the subject will be the 50% or higher of the total score.

Ordinary call: continuos assessment

Three theoretical and practical exams (Exam) spread along the course: 100%. The final exam scores will be weighted by the quality of the laboratory work (Lab) performed in the face-to-face laboratory sessions. Thus, the final score of every evaluation action is calculated as: Exam x Lab, where Lab is a weight in the range of [0,1].

Ordinary call: one final examination

Final exam: 100% (it includes theory and laboratory practices).

Extraordinary call

Final exam: 100% (it includes theory and laboratory practices).

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Lecture notes	Web resource	Slices prepared for the subject available in a Moodle platform
Y. C. Eldar and G. Kutyniok, Compressed Sensing: Theory and Applications. 2012	Bibliography	
V. M. Patel, Sparse Representations and Compressive Sensing for Imaging and Vision, vol. XXXIII, no. 2. 2013	Bibliography	
S. Foucart and H. Rauhut, A mathematical introduction to compressive sensing. New York, NY: Springer New York, 2013	Bibliography	
E. Candès and M. Wakin, An introduction to compressive sampling, Signal Process. Mag. IEEE, no. March 2008, pp. 21?30, 2008	Bibliography	
D. L. Donoho, Compressed Sensing, pp. 1?34, 2004	Bibliography	
R. F. Marcia, Compressed sensing for practical optical imaging systems: a tutorial, Opt. Eng., vol. 50, no. 7, p. 072601, Jul. 2011	Bibliography	
J. Romberg, Imaging via compressive sampling, IEEE Signal Process. Mag., no. March 2008, pp. 14?20, 2008	Bibliography	

J. Haupt and R. Nowak, Signal reconstruction from noisy random projections, IEEE Trans. Inf. Theory, vol. 52, no. 9, pp. 4036?4048, 2006	Bibliography	
K. Zhang, L. Zhang, and M. Yang, Real-time compressive tracking, Comput. Vision?ECCV 2012, pp. 866?879, 2012	Bibliography	
E. J. Candès, J. Romberg, and T. Tao, Robust uncertainty principles: Exact signal reconstruction from highly incomplete frequency information? IEEE Trans. Inf. Theory, vol. 52, no. 2, pp. 489?509, 2006	Bibliography	
E. Candès and J. Romberg, Sparsity and incoherence in compressive sampling, Inverse Probl., vol. 23, no. 3, pp. 969?985, 2007	Equipment	
D. L. Donoho and P. B. Stark, Uncertainty Principles and Signal Recovery, SIAM Journal on Applied Mathematics, vol. 49, no. 3. pp. 906?931, 1989	Bibliography	
Laboratory facilities	Equipment	Laboratory equipped with computers to develop the programming projects.