

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

105000441 - Image Understanding

DEGREE PROGRAMME

10II - Grado En Ingenieria Informatica

ACADEMIC YEAR & SEMESTER

2021/22 - Semester 2

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1. Description

1.1. Subject details

Name of the subject	105000441 - Image Understanding
No of credits	3 ECTS
Type	Optional
Academic year of the programme	Fourth year
Semester of tuition	Semester 8
Tuition period	February-June
Tuition languages	English
Degree programme	10II - Grado en Ingeniería Informática
Centre	10 - Escuela Técnica Superior De Ingenieros Informáticos
Academic year	2021-22

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Angel Mario Garcia Pedrero (Subject coordinator)	4211	angelmario.garcia@upm.es	Sin horario. Contact the professor by e-mail
Consuelo Gonzalo Martin	4207	consuelo.gonzalo@upm.es	Sin horario. Contact the professor by e-mail

* 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

- Reconocimiento De Formas
- Probabilidades Y Estadística I
- Inteligencia Artificial

3.2. Other recommended learning outcomes

- Machine Learning
- Signal and image processing
- Python

4. Skills and learning outcomes *

4.1. Skills to be learned

- CG-1/21 - Capacidad de resolución de problemas aplicando conocimientos de matemáticas, ciencias e ingeniería.
- CG-13/CE55 - Capacidad de comunicarse de forma efectiva con los compañeros, usuarios (potenciales) y el público en general acerca de cuestiones reales y problemas relacionados con la especialización elegida.
- CG-19 - Capacidad de usar las tecnologías de la información y la comunicación.
- CG-2/CE45 - Capacidad para el aprendizaje autónomo y la actualización de conocimientos, y reconocimiento de su necesidad en el área de la informática.
- CG-24/25/26/27 - Capacidad para trabajar en el contexto internacional, comunicándose en lengua inglesa y adaptándose a un nuevo entorno.

CG-6 - Capacidad de abstracción, análisis y síntesis

CG-7:10/16/17 - Capacidad para trabajar dentro de un equipo, organizando, planificando, tomando decisiones, negociando y resolviendo conflictos, relacionándose, y criticando y haciendo autocritica

Ce 12/16 - Conocer los campos de aplicación de la informática, y tener una apreciación de la necesidad de poseer unos conocimientos técnicos profundos en ciertas áreas de aplicación; apreciación del grado de esta necesidad en, por lo menos, una situación.

Ce 13/18 - Comprender lo que pueden y no pueden conseguir las tecnologías actuales, y las limitaciones de la informática, que implica distinguir entre lo que, inherentemente, la informática no es capaz de hacer y lo que puede lograrse a través de la ciencia y la tecnología futuras.

Ce 19/20 - Conocimiento de los tipos apropiados de soluciones, y comprensión de la complejidad de los problemas informáticos y la viabilidad de su solución.

4.2. Learning outcomes

RA284 - Capacitación para diseñar las líneas maestras de un proyecto.

RA276 - Dado un campo de aplicación de la informática, evaluar y diseñar el sistema informático más apropiado para resolver alguno de sus problemas, exponiendo las dificultades técnicas y los límites de la aplicación.

RA277 - Dado un problema real elegir la tecnología informática existente en el mercado mas apropiada para su solución y diseñar su desarrollo e integración, analizando la viabilidad de su solución, lo que se puede y no se puede conseguir a través del estado actual de desarrollo de la tecnología usada, y lo que se espera que avance en el futuro.

* 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

Image understanding, which is based on the results of image processing and analysis, attempts to interpret the meaning of an image at a high level in order to provide semantic information closely related to human thought, to help make decisions and to guide actions according to the understanding of the scenes. This course is an introduction to the fundamental concepts in image understanding. A variety of interesting vision problems and techniques will be studied. Specifically, the course will cover image characteristics, feature extraction, image classification, and object recognition.

5.2. Syllabus

1. Introduction

- 1.1. Motivation and Objectives
- 1.2. Definition of Image Understanding
- 1.3. Examples

2. Digital Images

- 2.1. Image Acquisition
- 2.2. Image Characteristics
- 2.3. Image representation

3. Linear Filters

- 3.1. Convolution
- 3.2. Sharpening
- 3.3. Noise reduction
- 3.4. Edge detection

4. Feature Descriptors

- 4.1. Keypoint detection
- 4.2. Local Descriptors
- 4.3. Texture
- 4.4. Convolutional Neural Networks

5. Image Segmentation

5.1. Grouping and features

5.2. Algorithms

6. Applications

6.1. Image Classification

6.2. Object recognition

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1	Unit 1 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	
2	Unit 2 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	Questionnaire Unit 2 Online test Continuous assessment Not Presential Duration: 00:30
3	Unit 3 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	
4	Unit 3 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	Questionnaire Unit 3 Online test Continuous assessment Not Presential Duration: 00:30
5		Lab Practices Duration: 02:00 Laboratory assignments	Individual tutoring Duration: 00:00 Additional activities	Lab work Individual work Continuous assessment Not Presential Duration: 00:00
6	Unit 4 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	
7	Unit 4 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	
8	Unit 4 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	Questionnaire Unit 4 Online test Continuous assessment Not Presential Duration: 00:30
9	Unit 5 Duration: 02:00 Lecture		Presentation Project Assignment Duration: 02:00 Additional activities Individual tutoring Duration: 00:00 Additional activities	
10	Unit 5 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	

11		Lab Practices Duration: 02:00 Laboratory assignments	Individual tutoring Duration: 00:00 Additional activities	Lab work Individual work Continuous assessment Not Presential Duration: 00:00
12	Unit 6 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	
13	Unit 6 Duration: 02:00 Lecture		Individual tutoring Duration: 00:00 Additional activities	Questionnaire Units 5 and 6 Online test Continuous assessment Not Presential Duration: 00:30
14			Compulsory Final Project tutoring Duration: 02:00 Additional activities	
15			Compulsory Final Project tutoring Duration: 02:00 Additional activities	
16				Evaluation Project Assignment Presentation Group presentation Continuous assessment Presential Duration: 02:00 Evaluation of Project Assignment Group work Continuous assessment Not Presential Duration: 02:00
17				Final Exam Written test Final examination Presential Duration: 02:00

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 schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
2	Questionnaire Unit 2	Online test	No Presential	00:30	3%	0 / 10	CG-1/21 CG-6
4	Questionnaire Unit 3	Online test	No Presential	00:30	4%	0 / 10	CG-1/21 CG-6
5	Lab work	Individual work	No Presential	00:00	20%	4 / 10	Ce 12/16 CG-6 Ce 19/20 CG-2/CE45 CG-1/21
8	Questionnaire Unit 4	Online test	No Presential	00:30	4%	0 / 10	CG-1/21 CG-6
11	Lab work	Individual work	No Presential	00:00	25%	4 / 10	Ce 12/16 CG-6 Ce 19/20 CG-2/CE45 CG-1/21
13	Questionnaire Units 5 and 6	Online test	No Presential	00:30	4%	0 / 10	CG-1/21 CG-6
16	Evaluation Project Assignment Presentation	Group presentation	Face-to-face	02:00	15%	4 / 10	Ce 12/16 CG-6 Ce 19/20 CG-2/CE45
16	Evaluation of Project Assignment	Group work	No Presential	02:00	25%	4 / 10	Ce 12/16 CG-6 Ce 19/20 CG-2/CE45 CG-1/21

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final Exam	Written test	Face-to-face	02:00	100%	5 / 10	Ce 12/16 CG-6 Ce 19/20 CG-2/CE45 CG-1/21

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
The grade of this exam will be 55% of the total grade, being 45% the grade obtained in lab works.	Written test	Face-to-face	02:00	100%	5 / 10	Ce 12/16 CG-6 Ce 19/20 CG-2/CE45 CG-1/21

7.2. Assessment criteria

Continuous evaluation:

The course will be evaluated by:

4 Questionnaires

2 Lab works

1 Final Project

Project assignments will be done in groups among those enrolled in the course at the beginning of the academic year (nature and number of components will be established at the beginning of the course, depending on the number of students enrolled).

In order to pass the course the requirements are:

To obtain a minimum of 50 points out of 100 in the added evaluation.

It is MANDATORY to do the lab works, while the project assignment is optional.

In each lab work as well as each project assignments, students must obtain a minimum of 40 points out of 100.

Final score will be calculated as follows:

15% Questionnaires (3% questionnaire unit 2 and 4% each of the other 3 proposed questionnaires)

45% Lab works (2 practices)

40% Final project: 25% Report + 15% Oral presentation

Class attendance is especially relevant for the subject, for this reason the final grade of the course will be affected by a multiplicative factor F, calculated as follows: $F = 1.2 \cdot [1 - (\text{Number of unexcused absences}) / (\text{Total number of classes})]$.

Final exam evaluation. Those students whose extraordinary circumstances cannot perform the continuous evaluation, and having done the final exam evaluation written petition during the first 15 days of the course, will perform the final exam evaluation without having the opportunity to do the continuous evaluation.

On these premises, the final exam evaluation will consist of an exam as stated by the head of studies. The grade of this exam will be 55% of the total grade, being 45% the grade obtained in lab works. The minimum grade to pass is 5/10. The Head of Studies will determine the dates on which the exam will be held.

Referred (re-sit) examination. If the course is not passed during the ordinary call (continuous evaluation or final exam evaluation), the student will have to deliver the lab works in case it has not been done and take an exam. The grade of this exam will be 55% of the total grade, being 45% the grade obtained in lab works. In this regard, it is mandatory to do the practices. The minimum the referred grade to pass is 5/10. The Head of Studies will determine the dates on which the exams will be held.

Measures against copies and fraud Rights and duties of college students are gathered on the statutes of the Universidad Politécnica de Madrid (BOCM de 15 de noviembre de 2010) and in the statutes of the college student (RD 1791/2010 de 30 de diciembre). Article 124 a) of UPM statutes fixes the duty of the student... "to follow with responsibility and taking advantage of the learning process, knowledge acquisition correspondent to its condition of college student"... and the article 13 of the statutes of the college student in its point d) also specifies as duty of the college student "abstain from the use or cooperation in fraudulent procedures in the evaluation assessments, in the assignments developed or in the official documents of the university". In the case that in the development of the evaluation assessments it is appreciated a breach in the duties as college student, the subject coordinator may communicate the headmaster as established in the article 74 (n) of UPM statutes to have the competences to "propose the initiation of a disciplinary procedure to any College member, by its own initiative or as instance from the "Comisión de Gobierno"" to the Rector, pursuant to the statutes and rules of application.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Moodle	Web resource	http://moodle.upm.es
Szeliski, R. (2010). Computer vision: algorithms and applications. Springer Science & Business Media.	Bibliography	Book available free online: http://szeliski.org/Book/
Zhang, Y. (2017). Image Understanding. Walter de Gruyter GmbH & Co KG.	Bibliography	https://books.google.es/books?id=B7UwDwAAQBAJ&lpg=PR5&ots=dIKZ3RRil&dq=Image%20understanding%20Yu-Jin%20Zhang&lr&pg=PR8#v=onepage&q=Image%20understanding%20Yu-Jin%20Zhang&f=false
Digital Image Processing, 4th Edition Rafael C. Gonzalez, Richard E. Woods, 4th Edition, Pearson (2017)	Bibliography	https://www.pearson.com/us/higher-education/program/Gonzalez-Digital-Image-Processing-4th-Edition/PGM241219.html

ImageProcessingBasics.com Digital image processing tutorials and interactive applets	Others	http://www.imageprocessingbasics.com
Scientific articles	Bibliography	Specific scientifics articles will be recommended for each project assignment
Python.	Others	https://www.w3schools.com/python/default.asp
OpenCV	Others	https://opencv-python-tutroals.readthedocs.io/en/latest/
Jupyter notebook	Others	Jupyter notebook. https://jupyter-notebook.readthedocs.io/en/stable/notebook.html
Google Colaboratory	Web resource	https://colab.research.google.com

9. Other information

9.1. Other information about the subject

This course presents contents related mainly to the following Sustainable Development Goals (SDGs):

SDG3, SDG6, SDG11, SDG12, SDG14 and SDG15. Good Health and Well-Being, Clean Water and Sanitation, Sustainable Cities and Communities, Responsible Production and Consumption, Underwater Life, Life of Terrestrial Ecosystems.

The topics addressed during this course could be used in different domains such as Medical Imaging and Earth observation, driven by the needs of Society and by the improvement in different technologies, these topics are an essential tool for understanding the different modalities of images that provide information about health and managing interactions between Earth and Man.

10. Adendas

- In order to achieve a better adjustment between the credits of this course and the effort made by the students to pass it, it has been decided to eliminate the class project that appear in the Learning Guide of the course and having three lab works instead of two, and add one more evaluation questionnaire. These changes imply some changes in the weighting of the different evaluable activities: 5 questionnaires and the 3 lab works. The weighting evaluation activities will be as follows: • 25% Questionnaires: 5% each one • 75% Lab works: 25% each one In the case of the of modality final exam evaluation (ordinary call), the weighting evaluation activities will be as follows: • 50% Lab works • 50% Theory Exam For those students who do not pass the course in the ordinary call the evaluation (re-sit examination) will be a Final Exam with a weight of 100%.