Universidad de Alcalá

TEACHING GUIDE

Image Processing and Computer Vision

Degree in
Telecommunication Systems Engineering

Universidad de Alcalá

Academic Year 2025/2026

4th Year - 1st Semester

Approved by the EPS School Board on June 16th, 2025

TEACHING GUIDE

Course Name:	**Image Processing and Computer Vision**
Code:	**390012**
Degree in:	**Telecommunication Systems Engineering**
Department and area:	**Teoría de la Señal y Comunicaciones** **Signal and Communications Theory**
Type:	**Optional (Oriented)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year, 1st Semester**
Teachers:	Sergio Lafuente Arroyo José Sáez Landete
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	Spanish/ English Friendly

1. COURSE SUMMARY

Computer vision is a field of engineering that includes methods for the acquisition, processing, analysis and extraction of information from images or video sequences. Such methods can range from the recognition and localization of specific objects in digital images to applications of video surveillance, people counting, vehicle control, etc.

This course is designed to make students understand and be able to apply the main techniques of image and video sequences processing in the field of computer vision. Likewise, during the development of the subject the student will familiarize with different image and computer vision libraries and applications.

Prerequisites and Recommendations:

It is recommended that the student had basics knowledge on computer programming in any language.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/352/2009:

en_TR3 - Aptitude to solve problems with initiative, decision making, creativity, and to communicate and to transmit knowledge, skills and workmanship, comprising the ethical and professional responsibility of the activity of the Technical Engineer of Telecommunication.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

en_CST1 - Ability to build, operate and manage telecommunications networks, services, processes and applications, understood as systems for capturing, transporting, representing, processing, storing, managing and presenting multimedia information, from the point of view of transmission systems .

en_CST6 - Ability to analyze, encode, process and transmit multimedia information using analog and digital signal processing techniques.

Learning Outcomes

After succeeding in this subject the students will be able to:

RA1. State the basic concepts of image generation and storage and digital video.

RA2. Know the main image processing techniques.

RA3. Identify the latest techniques for object recognition and information extraction semantics of images.

RA4. Design and implement different computer vision applications applied to real scenarios

3. CONTENTS

Contents Blocks. Both theoretical and practical. Includes large group classes and laboratory ones.	Total number of hours
Module 1 - Introduction to image processing: Concept of image and video. Introduction to programming applications. Python and OpenCV. Colour spaces. Segmentation. Image manipulation. Filtering and enhancing edges. Morphological processing.	• 16 hours
Module 2 - Object detection and recognition: Extraction of features for detection. Invariant descriptors. Introduction to pattern recognition. Advanced image classification techniques. Objects detection. Convolutional neural networks (Deep Learning).	• 14 hours
Module 3 - Building a Convolutional Neural Network: Configuration of the network. Training and validation processes. Application for classification.	• 8 hours
Module 4 - Motion detection and tracking: Motion detection and optical flow. Objects tracking. Super-resolution imaging. Human activity recognition.	• 10 hours
Module 5 - Camera model: Projection geometry. Camera geometric models. Stereo Vision.	• 10 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

The teaching strategy of the subject is divided into 3 blocks: large group sessions, work sessions in the laboratory and student's own work.

Sessions of large group in the classroom:

In the large group sessions, the main concepts related to the digital images processing and computer vision will be presented. The objective is to introduce the student to the theoretical foundations of the analysis of images and video sequences in a guided and reflective way. The assimilation of these concepts will end with their implementation during

the development of the activities in the laboratory sessions. The support with teaching materials will be fundamental to create reflective learning environments, where students and teachers can undertake a critical analysis that allows the student to link concepts autonomously.

Sessions of small group in the laboratory:

The work in the laboratory makes up the second learning scenario. The work sessions will be carried out in small groups, in which the student must work in a team. The objective is that the students explore the applicability of the concepts seen in the theoretical classes.

The work in the laboratory is designed from the modules that make up the contents of the subject. For each of the modules (Mn), students must complete a set of laboratory sessions, where they will learn the fundamental concepts related to the corresponding content module.

Student's own work:

All the activities corresponding to the sessions of the subject have been designed to be developed using free software, which gives the possibility to the student to have such software on their own computer and, therefore, helps the student's own work out of the laboratory.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Continuous assessment:

Due to the practical nature of the subject, the continuous assessment will be based mainly on the systematic observation of the student's work in the laboratory, and the development and results obtained with the laboratory sessions and the final project. In this sense, the student's ability to understand and be able to solve the problems raised in the activities, as well as the quality and

adequacy of the results obtained will be analysed. However, all the details related to the continuous assessment procedure that will be followed during the development of the subject will be informed during the presentation on the first day of class.

Final Evaluation:

For those students who do not opt for continuous assessment, as set out in the regulations of the evaluation of learning processes, the evaluation will consist of completing and pass a set of basic activities related to the content modules of the subject (PB).

Extraordinary call:

The extraordinary call will consist of the realization of the same tests and activities as those specified for the students who do not accept the continuous evaluation process in the ordinary call.

5.2. EVALUATION

EVALUATION CRITERIA

After having completed the course, the student must have deepened in the following knowledge and skills:

CE1. Understand the concepts of image and video sequences, and know the basic processing techniques.

CE2. Being able to develop different computer vision applications and knowing how to manage and configure different types of video sensors.

CE3. Know how to apply the various classification, recognition and detection techniques.

CE4. Understand the techniques and algorithms for motion detection and object tracking in video sequences.

CE5: Understand the geometric model of image formation using video cameras.

GRADING TOOLS

The main grading instrument to be used will be the results obtained (presented in a memory) in the laboratory sessions of each of the modules (Mn). For this reason, for the students who take part in the continuous assessment process, attendance, both for large group sessions, and especially for laboratory sessions, is mandatory. In case of inability to attend, it will be agreed between teacher and student how to retake lost sessions. In any case, students who do not attend a minimum of 80% of the laboratory sessions will have the grade of "Not Qualified".

For the marks of the memories, in addition to the attainment of the associated learning results, the following criteria will be considered:

- Clarity and order.
- Synthesis capacity.
- Quality of the results obtained.

GRADING CRITERIA

In the ordinary call - continuous assessment the relationship between the criteria, instruments and marks is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
CST1, CST6, TR3, TRU3, TRU4	RA1, RA2	CE1, CE2	M1	25%
	RA3	CE2, CE3	M2	25%
	RA3	CE2, CE3	M3	10%
	RA4	CE2, CE4	M4	20%
	RA1	CE2, CE5	M5	20%

In the ordinary call - final evaluation, the relationship between the criteria, instruments and marks is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
CST1, CST3, TR3, TRU3, TRU4	RA1, RA2, RA3, RA4	CE1, CE2, CE3, CE4, CE5	PB	100%

In the extraordinary call, the relationship between the criteria, instruments and marks is the same as for the ordinary call - final evaluation.

The teaching-learning methodology and the assessment process will be adapted as needed, in accordance with the guidelines of the Diversity Support Unit, to implement curricular adaptations for students with specific needs.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Gonzalez, R. C., Wood, R. E., Digital Image Processing", Addison Wesley Publishing Company, 1992.
- Hartley, R., Zisserman, A., "Multiple View Geometry in computer vision", Cambridge University Press, 2003.
- Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer, 2010.
- Bradski, G., Kaehler, A. “Learning OpenCV”. O'Really, 2008.
- Laganiére, R. “OpenCV 2 Computer Vision”. Packt, 2011.

6.2. Additional Bibliography

- David Forsyth and Jean Ponce, “Computer Vision: a modern approach”.
- Jain A. K., "Fundamentals of Digital Image Processing", Prentice Hall, 1989.
- Jahne B., "Digital Image Processing", Springer-Verlag, 1997.

- Castleman, K. R., "Digital Image Processing", Prentice Hall, 1996.
- Escalera, de la A., "Visión por Computador: Fundamentos y Métodos", Prentice Hall,2001.
- Taubman, D. S., Marcellin, M. W., "JPEG 2000 ", Kluwer Academic Publishers, 2002.

Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.