Universidad de Alcalá

# TEACHING GUIDE

# Computer Vision

## Degree in
## Electronic Communications Engineering (GIEC)
## Telecommunication Technologies Engineering (GITT)

## Universidad de Alcalá

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## Academic Year 2026/2027

4th Year - 1st Semester (GIEC+GITT)

Approved by the EPS School Board on June 15th, 2026

# TEACHING GUIDE

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| Course Name: | **Computer Vision** |
| Code: | **370009 (GIEC+GITT)** |
| Degree in: | **Electronic Communications Engineering (GIEC)**<br>**Telecommunication Technologies Engineering (GITT)** |
| Department and area: | **Electrónica**<br>**Electronic Technology** |
| Type: | **Optional (Oriented) (GIEC)**<br>**Optional (Generic) (GITT)** |
| ECTS Credits: | **6.0** |
| Year and semester: | **4th Year - 1st Semester (GIEC+GITT)** |
| Teachers: | Juan Manuel Miguel Jiménez |
| Tutoring schedule: | It will be communicated at the beginning of the course |
| Language: | English |

# 1. COURSE SUMMARY

Computer Vision aims to introduce students to the study of computer vision and design of digital image processing algorithms. The theoretical concepts explained in the lectures are scheduled later in the laboratory either in Python with OpenCV or in MATLAB.

Different alternatives for implementation of intelligent machine vision systems are detailed and analyzed. The main topics to be addressed include: fundamentals of digital image processing, image processing techniques in the spatial domain, image segmentation, recognition techniques and object tracking, 3D vision and its application in intelligent systems.

In order to make the most of the course, it is recommended (but not required) to have some knowledge about convolution, filtering, signal sampling, analog-to-digital and digital-to-analog conversions.

# 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_TR8** - Capacity of working in a multidisciplinary and multilingual team and of communicating, both in spoken and written language, knowledge, procedures, results and ideas related to telecommunications and electronics.

### 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_CSE1** - Ability to build, operate and manage systems for capturing, transporting, representing, processing, storing, managing and presenting multimedia information, from the point of view of electronic systems.

### Learning Outcomes

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

**RA1**. To know and understand the mathematical techniques that underlie digital image processing.

**RA2**. Apply the knowledge to digital processing techniques to solving specific problems with images.

**RA3**. Implement a machine vision application using a standard programming language and libraries for image processing.

# 3. CONTENTS

| Contents Blocks | Total number of hours |
|---|---|
| **Introduction**. | 1h |
| **Fundamentals of computer vision**.<br>• Introduction to computer vision.<br>• Lighting systems.<br>• Optics.<br>• Cameras.<br>• Image capture and geometry.<br>• Digitalization.<br>• Introduction to Color | 8h (4h T + 4h L) |
| **Basic techniques for image processing**.<br>• Spatial transformations.<br>• Types of filters.<br>• Geometric transformations on images.<br>• Histogram.<br>• Image enhancement.<br>• Detecting edges and corners.<br>• Morphological operators. | 8h (4h T + 4h L) |
| **Segmentation techniques**.<br>• Introduction to segmentation.<br>• Fundamentals of segmentation techniques.<br>• Region-based segmentation.<br>• Edge-based segmentation.<br>• Segmentation based on the histogram.<br>• Segmentation based on probabilistic methods. | 8h (4h T + 4h L) |
| **TC1+TCL1** | 1h |
| **Representation and image description.**<br>• Introduction.<br>• Basic descriptors.<br>• Fourier descriptors.<br>• Topological descriptors.<br>• Local features.<br>• Textures. | 8h (4h T + 4h L) |

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| **Machine Learning techniques in Computer Vision.**<br>• Basic concepts of Machine Learning.<br>• Region-based classifier (Neural Networks).<br>• Euclidean distance classifier, Mahalanobis and K-NN.<br>• Statistical classifier, Naïve/Normal Bayes.<br>• Decision trees.<br>• SVM Classifier (Support Vector Machines).<br>• Object detection. | 8h (4h T + 4h L) |
| **Motion detection and object tracking in videos.**<br>• Introduction.<br>• Background subtraction.<br>• Kalman Filter for Object Tracking. | 8h (4h T + 4h L) |
| **Coursework** | 6 h (L) |
| **Examination (Presentation of the coursework + TC2+TCL2)** | 2 hours |

# 4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

## 4.1. Credits Distribution

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| Number of on-site hours: | 58 hours (54 hours on-site + 4 examination hours) |
| Number of hours of student work: | 92 |
| Total hours | 150 |

## 4.2. Methodological strategies, teaching materials and resources

In the teaching and learning process the following training activities will be undertaken:

- Theoretical Classes and example solving.
- Practical Classes: laboratory and exercise solving.
- Tutorials: individual and/or in groups.

The following complementary resources, among others, will also be available for use:

- Individual or group tasks.
- Attendance at conferences, seminars or scientific discussions which are related to the module content.
- Watching videos about the content of this subject.

In the course of the year, both theoretical and practical activities and tasks will be proposed to the students. Different practical tasks will be undertaken at the same time as theoretical concepts are taught, so that students can experiment both individually and in groups, thus consolidating their knowledge of the concepts they have learned. *Gamification* concepts may be included in some

practices, based on this potentially positive methodology to motivate students.

In order to complete these practical tasks, the students will have access to an area in the laboratory with a computer and the required software for digital image processing.

In the course of the module, the students must make use of different bibliographic resources, so that they familiarize with the type of documentation that they will use professionally in their future.

# 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.

### Ordinary Call

Continuous Assessment:

The main assessment tools will be:

1. **Assessment Tests** (TC1 and TC2, TCL1 and TCL2), consisting of a set of questions covering the theoretical knowledge of the subject (TCs) and laboratory knowledge (TCLs).
2. **Laboratory Practices** (PL). These practices cover the knowledge acquired in the theoretical part of the course and have guided content, with small sections that students must complete on their own.
3. **A coursework** (PF). consisting of a program to solve a complete computer vision application, using all the knowledge acquired in the subject.

Assessment through final exam:

The main assessment tools are the following: two assessment tests (TC and TCL), laboratory practices (PL) and a coursework (PF).

### Extraordinary Call

The procedure will be the same as that described for the continuous assessment.

## 5.2. EVALUATION

### EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined:

**CE1.** Students should be able to correctly solve mathematical problems related to computer vision.
**CE2**. Students have to integrate conceptual knowledge explained in the different theoretical classes to solve in a creative and original way the problems that could arise.
**CE3**. Students have to implement in practice digital image processing algorithms that provide solutions to the problems raised. It will be carried out by integrating the acquired knowledge about the operation of machine vision systems, using library resources and software tools at their availability.
**CE4**. Students should be able to make clear and accurate reports on the work done in the laboratory.
**CE5**. Students have to present and explain their proposals for resolving problems in a clear and reasonable way.

## GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

1. Ordinary call. Continuous assessment, with two theoretical assessment tests (TC1,TC2), two tests related to different aspects studied in the Labs (TCL1, TCL2), laboratory practices (PL) and a coursework (PF).
2. Extraordinary call. One assessment theory test (TC), one laboratory test (TCL),laboratory practices (PL) and a coursework (PF).

## GRADING CRITERIA

In the **ordinary call-continuous assessment** the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

| Skill | Learning Outcomes | Evaluation criteria | Grading Tool | Contribution to the final mark |
|---|---|---|---|---|
| en_CSE1, en_TR3 | RA1, RA2 | CE1, CE2 | TC1 | 20% |
| | | | TC2 | 20% |
| | RA1-RA3 | CE1-CE4 | TCL1, TCL2, class work assesment | 30% |
| en_CSE1, en_TR3, en_TR8 | RA1-RA3 | CE1-CE5 | PF | 30% |

To consider the continuous assessment passed, (demonstrating the acquisition of competencies) students must meet the following conditions:

- Students must complete all laboratory practices, the two laboratory tests (TCL1 and TCL2) and the two partial evaluation tests (TC1 and TC2).
- Students have proved capable of solving problems, by integrating the acquired knowledge about the functioning of the computer vision systems, using library resources and software tools at their disposal. Students have to present and explain their reports in a clear and reasonable way. It is understood that students have gained these skills if they get more than 4 out of 10 in the laboratory (TCL1, TCL2, class work assesment and PF).
- Obtain a weighted overall score equal to or greater than 5 (out of 10) among all the continuous assessment instruments.

Within the continuous assessment model, students who do not participate in the evaluation process will be given an "**Absent Fail**" for the ordinary call. A student is considered not to have participated in the continuous evaluation process if they do not attend the two evaluation tests (TC).

In the **ordinary call-final evaluation**, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

| Skill | Learning Outcomes | Evaluation criteria | Grading Tool | Contribution to the final mark |
|---|---|---|---|---|
| en_CSE1, en_TR3 | RA1, RA2 | CE1, CE2 | TC | 40% |
| en_CSE1, en_TR3 | RA1, RA2 | CE1-CE4 | PL, TCL | 30% |
| en_CSE1, en_TR3, en_TR8 | RA1-RA3 | CE1-CE5 | PF | 30% |

With this model, students must obtain at least five out of ten points on average among all the assessment tools.

A student will be considered **'Absent Fail'** in this assesment model, if he/she does not complete the TC.

Extraordinary call

**1)** According to the **continuous assessment model**: Students who, having participated in the process of continuous assessment do not get a final grade higher than 5 out of 10 in the ordinary call. This call will consist of three parts, each of which may be recognized if the student has already passed the equivalent part in the ordinary call:

- Assessment Test (**TC**), consisting of a set of questions covering the theoretical knowledge of the subject.
- Laboratory Practices (**PL, TCL**). These practices cover the knowledge acquired in the theoretical part of the course and have guided content, with small sections that students must complete on their own. The TCL test covers different aspects studied in the Labs (PL) and proves that the student worked on and understood the Labs (PL).
- A coursework (**PF**). consisting of a program to solve a complete computer vision application, using all the knowledge acquired in the subject. A work report will be presented and an oral presentation will be made.

| Skill | Learning Outcomes | Evaluation criteria | Grading Tool | Contribution to the final mark |
|---|---|---|---|---|
| en_CSE1, en_TR3 | RA1, RA2 | CE1, CE2 | TC | 40% |
| en_CSE1, en_TR3 | RA1, RA2 | CE1-CE4 | PL, TCL | 30% |
| en_CSE1, en_TR3, en_TR8 | RA1-RA3 | CE1-CE5 | PF | 30% |

In this case, the relationship among the skills, learning outcomes, evaluation criteria and grading tools are the same as those in the ordinary call-final evaluation.

A student will be considered **'Absent Fail'** in this assesment model, if he/she does not complete the TC.

**2)** According to the **final assessment model**: The evaluation procedure with this type of assessment will be identical to the final assessment model of the ordinary call.

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


- Documentation specifically prepared by the subject's teaching staff, which will be supplied directly to the students, or will be published on the subject's webpage.
- Video-classes that cover the theoretical knowledge of this subject.
- David A. Forsyth and Jean Ponce. Computer vision: A Modern Approach. Prentice Hall. Pearson Education International.
- Richard Szeliski. Computer Vision: Algorithms and Applications, 2nd ed.


## 6.2. Additional Bibliography

**Books:**


- Rafael C. Gonzalez and Richard E. Woods. Digital Image Processing. Prentice Hall.
- William K. Pratt. Digital Image Processing. Wiley Interscience.
- Richard Hartley and Andrew Zisserman. Multiple View Geometry in Computer Vision. Cambridge University Press
- Linda G. Shapiro, George C. Stockman. Computer Vision. Prentice Hall.
- Oliver Faugeras and Quang-Tuan Loung. The geometry of multiple Images. The MIT press.
- Kenneth R. Castleman. Digital Image Processing. Prentice Hall.
- Dona H. Ballard and Christopher M. Brown. Computer Vision. Prentice Hall
- Oliver Faugeras. Three- Dimensional Computer Vision. A geometric View point. The MIT press.
- Andrew Blake and Alan Yuille. Active Vision, The MIT Press.
- Robert M. Haralick and Shapiro. Computer and Robot Visison (vol I y II).
- OpenCV-Python Tutorials. https://docs.opencv.org/4.x/d6/d00/tutorial_py_root.html.


**websites:**


- MATLAB Image Processing Toolbox. (https://es.mathworks.com/).
- IEEE Xplore (https://ieeexplore.ieee.org).

## 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.