Universidad de Alcalá

TEACHING GUIDE

Computer Vision Systems

Bachelor's Degree in
Computer Science
Computer Engineering
Information Systems Engineering
Information Systems (G58)

University of Alcalá

Academic Year 2019/2020

4th Year – 1st Semester

TEACHING GUIDE

Name of the subject:	**Computer Vision Systems**
Code:	**780029**
Qualification concerned:	**Degree in Computer Science** **Degree in Computer Engineering** **Degree in Information Systems Engineering** **Degree in Information Systems (G58)**
Department and Knowledge Area:	**Electronics / Electronic Technology**
Type:	**Optional**
ECTS credits:	**6**
Year and semester:	**4th Year / 1st semester**
Teaching staff:	**See website:** http://www.depeca.uah.es
Teaching timetable:	**See website:** http://www.depeca.uah.es
Language:	**English**

1. INTRODUCTION

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 programmed later in the laboratory either in C/C++ with OpenCV or 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 and frequency domains, 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, discrete Fourier transform, analog-to-digital and digital-to-analog conversions.

2. SKILLS

General skills:

CG4 Ability to define, evaluate and select hardware and software platforms for the development and implementation of systems, services and applications, according to the knowledge acquired as provided in paragraph 5 of resolution BOE-A-2009-12977.

CG9 Ability to solve problems with initiative, decision making, autonomy and creativity. Ability to communicate and transmit knowledge and skills of the profession of Technical Engineer.

Specific skills:

CIC1 Ability to design and build digital systems, including computers, microprocessor-based systems and communications systems.

CIC7 Ability to analyze, evaluate, select and configure hardware platforms for development and Running applications and services.

CC3 Ability to evaluate the computational complexity of a problem, meet algorithmic strategies that can lead to resolution and recommend, develop and implement one that guarantees the best performance according to the requirements.

CC4 Ability to know the basics, paradigms and own techniques of intelligent systems and analyze, design and build systems, services and applications that use these techniques in any scope.

CTI6 Ability to conceive systems, applications and services based on network technologies, including Internet, web, e-commerce, multimedia, interactive services and mobile computing.

Learning outcomes:

When the students finish this course successfully, they will be able to:

LO1: To know and understand the mathematical techniques that underlie digital image processing.

LO2: Apply the knowledge to digital processing techniques to solving specific problems with images..

LO3: Implement a machine vision application using a standard programming language and libraries for image processing.

3. CONTENTS

Sections of contents	Total number of classes, credits or hours
Introduction	1 hour
Fundamentals of computer vision. • Introduction to computer vision. • Lighting systems. • Optics. • Cameras. • Image capture and geometry. • Radiometry. • Photometry. • Digitalization. • Introduction to Color.	5h (2h T + 3h L)
Basic techniques for image processing. • Spatial and frequential transformations. • Types of filters. • Geometric transformations on images. • Histogram. • Image enhancement. • Detecting edges and corners. • Morphological operators.	10h (4h T + 6h L)
Segmentation techniques. • Introduction to segmentation. • Fundamentals of segmentation techniques. • Region-based segmentation. • Edge-based segmentation. • Segmentation based on the histogram. • Segmentation based on probabilistic methods.	10h (4h T + 6h L)
Test 1	1h
Representation and image description. • Chain codes. • Signatures. • Basic descriptors. • Fourier descriptors. • Topological descriptors. • Moments. Invariant moments.	6h (2h T + 4h L)
Machine Learning techniques in Computer Vision. • Basic concepts of Machine Learning. • Region-based classifier (Neural Networks). • Euclidean distance classifier, Mahalanobis and K-NN. • Statistical classifier, Naïve/Normal Bayes. • Clustering by GMM-EM. • Decision trees. • SVM Classifier (Support Vector Machines).	8h (4h T + 4h L)

Geometry of the camera. • Pinhole camera model. • Homogeneous coordinates. • 3D Euclidean transformation. • Euclidean transformation in homogeneous coordinates. • Projective transformation. • Perspective, affine and similarity projections. • Intrinsic and extrinsic parameters of a camera.	8h (4h T + 4h L)
Coursework	8h (L)
Examination (Presentation of the coursework + Test 2)	3 hours

4. TEACHING AND LEARNING METHODOLOGIES. – TRAINING ACTIVITIES

4.1. Distribution of credits (in hours)

Number of contact hours:	60 hours (56 contact hours + 4 hours for assessment).
Number of private study hours per student:	90 hours.
Total hours:	150 hours.

4.2. Methodological strategies, didactic 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: after completing a project, students can present it publically in front of the rest of their classmates in order to stimulate debate.
- Attendance at conferences, seminars or scientific discussions which are related to the module content.

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.

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

The assessment process is based on the continuous assessment of students. Nevertheless, the students will have a period of fifteen days to write to the Director of the Polytechnic School to request the right to make use of the final assessment model, bringing forward any reasons which they believe to be appropriate according to what is stated in the assessment process regulations (approved by the members of the board, on March 24th, 2011, article 10, paragraph 2). The evaluation of the learning process for all the students who do not make such a request or whose application is denied will instead be carried out, by default, in accordance with the continuous assessment model.

5.1 ASSESSMENT CRITERIA

The objective of the assessment process is to analyze what competencies the students have acquired and what level they have reached. The assessment criteria are the following:

AC1: Students should be able to correctly solve mathematical problems related to computer vision.

AC2: 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.

AC3: 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.

AC4: Students should be able to make clear and accurate reports on the work done in the laboratory.

AC5: Students have to present and explain their proposals for resolving problems in a clear and reasonable way.

5.2 ASSESSMENT TOOLS

Grading instruments to be applied to each of the evaluation criteria are the following:

1. Two Partial Evaluation Tests (PET), consisting of a set of questions covering the theoretical knowledge of the subject.
2. Four Laboratory Practices (LP). 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 (CW) 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.

5.3 ASSESSMENT STRATEGY

A table for each assessment model is included below. Each table shows the relationship between the different instruments, assessment criteria and the percentage of the grading assigned to each part.

Ordinary examination session:

1) According to the continuous assessment model:

Competency	**Learning outcomes**	**Assessment criteria**	**Assessment tools**	**Weight in the final grade**
CC3, CC4, CIC7	LO1, LO2	AC1, AC2	PET 1	15%
			PET 2	15%
	LO1-LO3	AC1-AC4	LP	30%
CIC1, CTI6, CG4, CG9	LO1-LO3	AC1-AC5	CW	40%

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

- Students must complete all laboratory practices and the two partial evaluation tests (PET1 and PET2).
- 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 practices (LP and CW). It is understood that a student has exceeded these competences if he/she obtains a final weighted grade resulting from the two parts of the laboratory (30% from LP + 40% from CW)

equal to or greater than 40% out of the maximum obtainable from the laboratory grade.

- 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 examination session. A student is considered not to have participated in the continuous evaluation process if they do not attend the two evaluation tests (PETs).

2) According to the final assessment model

The criteria for grading the subject for students who follow the final (not continuous) assessment model consist of passing a final test, whose contents are as follows:

a) A general exam (GE) consisting of questions and/or problems, which will assess the acquisition of competencies related to the theoretical classes and practical exercises, broadly covering all the studied topics.
b) A Lab test (LT) which will assess the acquisition of competencies related to the practical laboratory classes.
c) A coursework (CW) consisting of a program to solve a complete computer vision application, similar to that in the continuous assessment model.

The following table shows the relationship between the different instruments, assessment criteria and the percentage of the grading assigned to each part:

Competency	**Learning outcomes**	**Assessment criteria**	**Assessment tools**	**Weight in the final grade**
CC3, CC4, CIC7	LO1, LO2	AC1, AC2	GE	30%
	LO1-LO3	AC1- AC4	LT	30%
CIC1, CTI6, CG4, CG9	LO1-LO3	AC1-AC5	CW	40%

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

Extra-ordinary examination session:

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, may take the extraordinary session in July. 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:
   a) A general exam (GE) consisting of questions and/or problems, which will assess the acquisition of competencies related to the theoretical classes and

practical exercises, broadly covering all the studied topics. This exam may be recognized if the student passed the two PETs in the ordinary session.

b) A Lab test (LT) which will assess the acquisition of competencies related to the practical laboratory classes. This exam may be recognized if the student passed the laboratory practices in the ordinary session.

c) Delivery of a final work, with the same characteristics as that of the ordinary examination (CW).

Competency	**Learning outcomes**	**Assessment criteria**	**Assessment tools**	**Weight in the final grade**
CC3, CC4, CIC7	LO1, LO2	AC1, AC2	GE	30%
	LO1-LO3	AC1- AC4	LT	30%
CIC1, CTI6, CG4, CG9	LO1-LO3	AC1-AC5	CW	40%

2) **According to the final assessment model:** The grading procedure and criteria with this type of assessment will be identical to the final assessment model of the ordinary examination session.

6. BIBLIOGRAPHY

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.
- David A. Forsyth and Jean Ponce. ***Computer vision: A Modern Approach***. Prentice Hall. Pearson Education International.
- Richard Szeliski. ***Computer Vision: Algorithms and Applications***. Draft c 2010 Springer.

Further Reading (optional)

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 Balke and Alan Yuille. ***Active Vision***, The MIT Press.
- Robert M. Haralick and Shapiro. ***Computer and Robot Visison (vol I y II)***.
- Robert Laganière. ***OpenCV 2 Computer Vision Application Programming Cookbook***. PACKT Publising. 2011
- MATLAB Image Processing Toolbox. (http://www.mathworks.es/products/image)

Páginas web:

- The computer vision home page (http://www.cs.cmu.edu/~cil/vision.html)
- IEEE Xplore (http://ieeexplore.ieee.org)