

Degree programme	Type	Course
Bachelor in Artificial Intelligence	OB	2

Contact lecturer

Name : Guillermo Torres

Email : guillermo.torres@uab.cat

Group languages

You can consult this information at the [end](#) of the document.

Prerequisites

There are no prerequisites. This subject is self-contained, although it is recommended that students have passed the first-year subjects related to mathematics and programming.

Objectives

The general objective of the subject is to introduce students to the fundamentals of artificial vision and computer vision, providing them with the knowledge and tools needed to understand, implement and analyse basic techniques for image processing, representation and analysis.

The subject aims to enable students to relate the mathematical and algorithmic foundations of artificial vision to their practical application in visual recognition problems. To this end, the processes of digital image formation and representation, filtering, feature extraction, visual description and the resolution of basic computer vision problems will be addressed progressively.

By the end of the subject, students should be able to:

- understand the basic principles of the human visual system and their conceptual relationship with artificial vision systems;
- identify the main elements involved in the formation, acquisition and representation of digital images;
- apply basic image processing techniques, including linear filtering, non-linear filtering and morphological operations;
- extract and analyse relevant visual features, such as edges, corners and blobs;
- use colour, texture and shape descriptors to represent visual information;
- formulate and solve basic computer vision problems, including detection, classification and Bag of Words representation;
- implement artificial vision algorithms in Python, interpret their results and analyse their limitations;
- integrate theoretical and practical concepts to design simple solutions to artificial vision problems;
- develop a critical attitude towards the results obtained, considering the effect of parameters, input data and methodological decisions.

Learning outcomes

- CM12 (Build solutions to complex artificial intelligence problems based on the selection of the most appropriate image processing and computational learning techniques applied to computer vision.) Build solutions to complex artificial intelligence problems based on the selection of the most appropriate image processing and computational learning techniques applied to computer vision.

- KM29 (Identify the mathematical and algorithmic underpinnings on which low-level image processing, optimisation, and computational learning techniques applied to computer vision are based.) Identify the mathematical and algorithmic underpinnings on which low-level image processing, optimisation, and computational learning techniques applied to computer vision are based.
- SM32 (Use existing image processing algorithms and techniques, as well as deep learning architectures and models for the design and implementation of computer vision systems for different types of visual recognition problems.) Use existing image processing algorithms and techniques, as well as deep learning architectures and models for the design and implementation of computer vision systems for different types of visual recognition problems.
- SM33 (Perform data preparation, training, and model validation and analysis on all types of machine vision problems.) Perform data preparation, training, and model validation and analysis on all types of machine vision problems.

Contents

1. Introduction to Artificial Vision

- Human Visual System
- Marr's Model

2. Formation and Representation of the Digital Image

- Light, Scene and Colour
- Optics and Cameras
- Sampling and Quantisation
- Types of Images

3. Image Processing

- Linear Filtering
- Non-linear Filtering

4. Feature Extraction

- Edges
- Corners
- Blobs

5. Feature Descriptors

- Colour
- Texture
- Shape

6. Introduction to Basic Computer Vision Problems

- Detection
- Classification
- Bag of Words (BoW) Representation

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Autonomous study and preparation	53	2.12	KM29, SM32

Theory and Seminars	26	1.04	KM29, SM32
Completion of Assessed Problems	8	0.32	CM12, KM29, SM32, SM33
Completion of basic exercises	10	0.4	CM12, KM29, SM32
Study of the subject	20	0.8	CM12, KM29, SM32, SM33
Practicum in group	21	0.84	CM12, SM32, SM33

The subject will follow an active learning methodology based on the guided and progressive resolution of problems. The contents will be organised into thematic blocks combining conceptual explanations, worked examples, case discussions and practical activities related to the fundamentals of artificial vision.

After the expository sessions, students may work on optional reinforcement problems. These problems will have a formative purpose: to facilitate autonomous practice, consolidate the concepts covered in class, detect doubts and prepare for subsequent assessable activities. Their completion will be voluntary and will not replace the established assessment activities.

In addition, throughout the course, assessable problems associated with the main content blocks will be proposed. These problems must be submitted by the indicated deadlines and will form part of the continuous assessment of the subject. Their objective will be to assess the students' ability to apply techniques for image formation and representation, image processing, filtering, feature extraction and description, and the resolution of basic computer vision problems.

After the submission of the assessable problems, correction and feedback sessions will be held. In these sessions, the resolution criteria, common errors and improvement strategies will be discussed. The feedback will be oriented towards enabling students to apply the corrections received in subsequent activities.

Once several sets of problems have been worked on and corrected, individual assessment activities will be carried out to verify the degree of understanding, application and integration of the contents. These activities will be aligned with the contents explained, the reinforcement problems and the assessable problems previously submitted.

The methodology may be adapted during the semester depending on the pace of the group, the difficulties detected and the results obtained in the formative and assessable activities. Communication of materials, submissions, instructions, feedback and follow-up activities will be carried out through the UAB Virtual Campus.

Annotation: within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes
Practicum evaluation	See evaluation part of the memory	4	0.16	CM12, KM29, SM32, SM33
Second Midterm Exam	See evaluation part of the memory	2.5	0.1	CM12, KM29, SM32
Resit Exam	See evaluation part of the memory	3	0.12	CM12, KM29, SM32, SM33
First Midterm Exam	See evaluation part of the memory	2.5	0.1	KM29, SM32

A continuous assessment procedure will be followed, in which the activities carried out throughout the course will contribute to the final grade. This subject does not provide for the single-assessment system.

The final grade for the subject will be calculated from two main components:

- theory: 70% of the final grade;
- practice: 30% of the final grade.

Calculation of the final grade (FM)

All grades are expressed out of 10 points.

$$FM = 0.7 * EX + 0.3 * PR$$

$$EX = 0.5 * EX1 + 0.5 * EX2 + OP_{extra}$$

$$PR = 0.2 * PB1 + 0.2 * PB2 + 0.2 * PB3 + 0.4 * PB4$$

The subject is passed if and only if the following three conditions are met simultaneously:

1. theory passed (according to the criteria defined in the section "Theory assessment");
2. practice passed (according to the criteria defined in the section "Practice assessment");
3. $FM \geq 5.0$.

where:

- EX1 is the grade of the first partial exam;
- EX2 is the grade of the second partial exam;
- OP_{extra} corresponds to the additional points obtained through optional reinforcement problems;
- EX is the theory grade;
- PB1, PB2, PB3 and PB4 correspond to the grades of the assessable problems;
- PR is the grade of the assessable problems;
- FM is the final grade for the subject.

Theory assessment:

- For the purposes of the calculation above, if a student resits a partial exam, the grade obtained in the resit of that partial exam will replace the grade initially obtained.
- An exam is considered passed if the grade obtained is equal to or higher than 5.0 points.
- The partial exams EX1 and EX2 are passed independently.
- Passing a partial exam means that the student will not have to sit an exam again for that part of the subject. If the grade of a partial exam is lower than 5.0, the student must resit that entire partial exam in the resit examination.
- The resit examination is not global: each student will fully resit the partial exam or partial exams that have not been passed.
- The theory is considered theory passed only when both partial exams have been passed, either in the ordinary assessment or through the resit of the corresponding partial exam.
- The optional reinforcement problems (OP_{extra}) add additional points to the theory grade (EX), but they may not be used to add points to partial exams, the resit examination or assessable problems in order to reach the required minimum grade. The optional problems cannot be resat.

Practice assessment:

- It is compulsory to submit each assessable problem: PB1, PB2, PB3 and PB4. Otherwise, this part of the course cannot be passed.
- The assessable problems must be submitted through the Virtual Campus.
- Late submissions may receive a maximum score of 5 points.
- The assessable problems cannot be resat.
- In case of doubts regarding authorship or individual contribution within the group, the grade will become individual, assigning the mark according to the contribution of each member.
- Practice is considered practice passed if all assessable problems have been submitted (PB1, PB2, PB3 and PB4) and $PR \geq 5.0$.

Other relevant aspects:

- Practices, exercises or exams from previous academic years will not be recognised.
- If an exam or a part of the practice is not submitted, the grade for that part will be zero.
- The final grade will be "not assessable" if the student has not submitted any assessable activity.
- The grade of Honours Distinction (MH) will be awarded at the lecturer's discretion to students with a final grade higher than 9.0, taking into account all the activities carried out.
- The submission and assessment dates will be published on the Virtual Campus and may be modified in case of incidents, always informing students through that same channel.
- For written exams, a date and place will be indicated for students to review their exam; if the student does not attend, no later review will be carried out.
- Plagiarism, copying or any irregularity in assessable activities will result in a grade of zero for that activity, with no possibility of reassessment in the same academic year, and, where applicable, a failing grade for the subject.
- Under no circumstances may generative artificial intelligence (AI) be used to replace the student's learning activity. Tasks suspected of having been generated by these techniques will be assessed with a 0.

Use of AI:

- Artificial intelligence tools may be used as support tools for learning, for example to improve writing, style, clarity of exposition, linguistic correctness or to obtain assistance with technical aspects. Under no circumstances may they replace and/or supplant the student's learning activity, or the student's acquisition of the specific knowledge of the subject.
- It is not acceptable to use artificial intelligence tools to generate content for work that is subject to assessment. Assessable tasks/activities suspected of having been generated by AI instead of by the student will be considered copying and will be assessed with a 0.

Bibliography

Simon J.D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012. (<http://www.computervisionmodels.com/>)

David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach (2nd Edition), Prentice Hall 2011.

Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing (3rd Edition), Prentice Hall 2007.

Richard Szeliski, Computer Vision: Algorithms and Applications, Springer (Texts in computer Science) 2011. (<http://szeliski.org/Book/>)

Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016. (<http://www.deeplearningbook.org>)

Aurélien Géron, Hands-On Machine Learning with Scikit-Learn & TensorFlow, O'Reilly, 2017.

Online courses:

Online course, Coursera MOOC: Image and Video Processing: From Mars to Hollywood with a Stop at the Hospital. (<https://www.coursera.org/course/images>)

Online course, Coursera MOOC: Object Detection (UAB). (<https://www.coursera.org/learn/deteccion-objetos>)

Online course, Coursera MOOC: Fundamentals of Digital Image and Video Processing. (<https://www.coursera.org/course/digital>)

Online course, edX MOOC: Introduction to Computer Vision: Application Development with OpenCV. (<https://www.edx.org/course/introduccion-la-vision-por-computador-uc3mx-isa-1x>)

Software

Python will be used for programming the algorithms. The use of the Spyder development environment is recommended, as it integrates an editor, an interactive console, a variable explorer, and runtime debugging tools. Other equivalent environments may also be used, provided that they allow smooth interaction with the Python interpreter and step-by-step code debugging. The use of Jupyter Notebooks is not allowed for assessable submissions.

Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this [link](#). To access the information, you will need to enter the course CODE

Type of teaching	Group	Language	Semester	Shift
(TE) Theory	1	English	first semester	afternoon
(PAUL) Classroom practices	1	English	first semester	afternoon
(PLAB) Practical laboratories	1	English	first semester	afternoon
(PLAB) Practical laboratories	2	English	first semester	afternoon