Academic Year/course: 2021/22

69151 - Computer Vision

Syllabus Information

Academic Year: 2021/22
Subject: 69151 - Computer Vision
Faculty / School: 110 - Escuela de Ingeniería y Arquitectura
Degree: 615 - Master's in Robotics, Graphics and Computer Vision/ Robótica, Gráficos y Visión por Computador
ECTS: 6.0
Year: 1
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

The objective is the computational processing of images or digital video sequences for the inference of geometric properties, both for the observed 3D scene, and for the trajectory that the camera follows during the filming of the images. More specifically covering:

1. The physical principles and models of camera imaging.
2. The mathematical and probabilistic foundations for coding the geometric information and its uncertainty.
3. The fundamentals of image processing.
4. The usual algorithmic and computational techniques in computer vision.

These approaches and objectives are aligned with some of the Sustainable Development Goals, SDG, of the 2030 Agenda (https://www.un.org/sustainabledevelopment/es/) and certain specific goals, in such a way that the acquisition of the Learning outcomes of the subject provides training and competence to the student to contribute to a certain extent to their achievement:

- Objective 9: Industry, innovation and infrastructure
  - Target 9.5 Increase scientific research and improve the technological capacity of industrial sectors in all countries, particularly developing countries, including by fostering innovation and significantly increasing, by 2030, the number of people working in research and development per million inhabitants and the spending of the public and private sectors in research and development

1.2. Context and importance of this course in the degree

Compulsory course of 6 ECTS, it is taught in the first semester. It provides fundamental background for the processing of images and digital image sequences.

1.3. Recommendations to take this course

Python programming.

2. Learning goals

2.1. Competences

The student will acquire the following basic and general competences:

- CB7 - That students know how to apply the acquired knowledge and ability to solve problems in new or little-known settings within broader (or multidisciplinary) contexts related to their area of study.
- CB9 - That students know how to communicate their conclusions and the latest knowledge and reasons that support them to specialized and non-specialized audiences in a clear and unambiguous way.
- CB10 - That students possess the learning skills that allow them to continue studying in a way that will have to be largely self-directed or autonomous.
- CG01 – Acquisition of advanced and demonstrated knowledge, in a context of scientific and technological research or highly specialized, a detailed and well-founded understanding of the theoretical and practical aspects and of the working methodology in the fields of Robotics, Graphics and / or Computer Vision, allowing them to be innovative in a context of research, development and innovation.
- CG03 - Ability to evaluate and select the appropriate scientific theory and the precise methodology of their fields of study to formulate judgments based on incomplete or limited information, including, when necessary and pertinent, considerations on social or ethical responsibility linked to the solution that is proposed in each case.
- CG05 - Ability to transmit in English, orally and in writing, in a clear and unambiguous way, to a specialized audience or not, results from scientific and technological research or the most advanced field of innovation, as well as the most relevant foundations on which they are based.
- CG06 – To have developed sufficient autonomy to participate in research projects and scientific or technological collaborations within their subject area, in interdisciplinary contexts and, where appropriate, with a high component of knowledge transfer.
- CG07 - Ability to take responsibility for your own professional development and specialization in one or more fields of study.
- CG08 – To possess the aptitudes, skills and method necessary to carry out multidisciplinary research and / or development work in the fields of Robotics, Graphics and / or Computer Vision.
- CG11 - Ability to manage and use bibliography, documentation, databases, software and hardware specific to the fields of Robotics, Graphics and / or Computer Vision.
- CG12 - Ability to work in a multidisciplinary group and in a multilingual environment.

The student will acquire the following specific competences:

- CE01 - Ability to apply mathematical and artificial intelligence methods to model, design and develop Robotics, Graphics and / or Computer Vision systems and applications.
- CE02 - Ability to design and develop new methods and algorithms applicable to autonomous systems or virtual and augmented reality.
- CE06 - Ability to conceive, design and develop software, products and systems in the field of Computer Vision.
- CE09 - Ability to autonomously carry out a work of initiation to research and / or development in the field of Robotics, Graphics, or Computer Vision, in which the skills acquired in the degree are synthesized and integrated.

2.2. Learning goals

1. Know the parametrization and the mathematical models of the images formation with 3D projective cameras, both in its geometric and photometric aspects.
2. Know the algorithms of image processing and image feature detection.
3. Know the formulation of multi-view geometry and the estimation of 3D information from projective images.
4. Know the formulation of stereo correspondences and optical flow.
5. Know specific models and algorithms for omnidirectional vision.

6. Design and develop systems that make inferences about the 3D structure of the scene from images.
7. Evaluate the performance of computer vision systems in operation.
8. Propose new algorithms that address unresolved aspects of the operation of a 3D vision system and the evaluation of its performance evaluation of its performance.
9. Develop software that processes real images using the most popular libraries of computer vision, mathematical operations and non-linear optimization.

2.3. Importance of learning goals

Computer vision is a combination of computing, image processing, geometry, and probability. The course provides the theoretical support to understand the combined fundamentals, it also provides programming skills to produce software implementations and the methodologies to assess and exploit the results. Visual information is basic to robotic systems. Computer vision has a very close relationship with computational photography, virtual reality and augmented reality because it shares the same physical and mathematical models.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

A continuous assessment system is applied. It is composed of the following assessment activities programmed throughout the course:
E01 -Laboratory tests/interviews, in which each practice session is assessed (25%). The understanding of the theoretical foundations, the ability to produce an efficient implementation and experimental validation will be considered.
E02 -Course assignment, a project which globally combines the contents of the course (70%). - The student faces a new problem, the assessment criteria are:

1. Ability to tackle new situations using the course theoretical contents and algorithms.
2. Implementation efficiency.
3. Experimental validation.
4. Presentation of the results in an oral talk and/or a written report.

E03 - Presentation of a scientific article (5%). The ability to identify the most relevant aspects of the article, its connection with the contents of the course and the oral presentation quality will be assessed.

Students will also be able to pass the course through a global assessment carried out on the day designated by the school, passing the same activities above mentioned in the continuous assessment.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards the achievement of the learning objectives. A wide range of teaching and learning tasks are implemented. Students are expected to participate actively in the class throughout the semester.

Classroom materials will be available via Moodle. These include a repository of the lecture notes used in class, the course syllabus, as well as other course-specific learning materials, including a discussion forum.

Further information regarding the course will be provided on the first day of class.

4.2. Learning tasks

A01 Lectures (30 hours) Theoretical content sessions. The concepts and foundations will be presented. Student participation will be encouraged through questions and short discussions.

A02 Practice sessions (6 hours) Small Python programs to exercise the basic concepts of the course.

A03 Laboratory practices (15 hours). Exercises of medium complexity. They require combining theoretical concepts with standard computer vision libraries, producing software able to actual image sequences. The performance is evaluated experimentally. 6 sessions have been scheduled.

A05 Course assignment (50 hours). Course project facing an open problem. The students have to combine all the theoretical background and algorithms in the course.

A06 Tutorials (4 hours). Personalized debate with the lecturers.

A07 Autonomous work (40 hours) .- The autonomous work of the student will be devoted to:

1. In-depth study of the contents and readings prior to the lectures, using the bibliography.
2. Completion of the exercises proposed in the practice sessions.
3. Preparation and completion of the laboratory practice assignments.
4. Reading of scientific articles related with the course contents.

A08 Assessment (5 hours). Time dedicated to continuous assessment activities, in which the student presents the outcome of the assignments.

4.3. Syllabus

1. Image formation, geometric and photometric models.
2. Image processing, local features.
3. Alignment and calibration based on local features.
4. Structure from motion.
5. Multi-view geometry.
6. Estimation of dense motion. Optical flow and stereo correspondence.
7. Omnidirectional vision.

4.4. Course planning and calendar

Further information concerning the timetable, classroom, office hours, assessment dates and other details regarding this course will be provided on the first day of class or please refer to http://moodle.unizar.es/

4.5. Bibliography and recommended resources

1. Szeliski, Richard. Computer vision : algorithms and applications London. Springer, cop. 2011.
2. Hartley, Richard and Zisserman, Andrew. Multiple view geometry in computer vision. 2nd ed. Cambridge. Cambridge University Press, 2003.
3. Kaehler A and Bradski Gary. Learning OpenCV 3: Computer Vision in C++ with the OpenCV. O?Reilly Media. 2017.
4. Robert Johansson. Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib,Apress; Edición: 2nd ed. 2018.
5. Howse Joseph, Minichino, Joe. Learning OpenCV 4 Computer Vision with Python 3: Get to grips with tools, techniques, and algorithms for computer vision and machine learning, 3rd Edition, Packt Publishing. 2020.