UNIVERSIDAD DE CASTILLA - LA MANCHA

GUÍA DOCENTE

1. General information

Course: AUTONOMOUS ROBOTICS
Code: 42361
Type: ELECTIVE
ECTS credits: 6
Degree: 406 - UNDERGRADUATE DEGREE IN COMPUTER SCIENCE AND ENGINEERING (AB)
Academic year: 2022-23
Center: 604 - SCHOOL OF COMPUTER SCIENCE AND ENGINEERING (AB)
Group(s): 17
Year: 4
Duration: C2
Main language: English
Second language:
Use of additional languages:
English Friendly: Y
Web site: https://campusvirtual.uclm.es
Bilingual: N

Lecturer: **JESUS MARTINEZ GOMEZ** - Group(s): **17**

Building/Office	Department	Phone number	Email	Office hours
Agrupación Politécnica/ Desp. 1.E.4	SISTEMAS INFORMÁTICOS	967599365	jesus.martinez@uclm.es	See https://www.esiiab.uclm.es/pers.php?codpers=723&curso=2022-23

2. Pre-Requisites

Students should have a solid background in computer programming and algorithms, and basic knowledge in calculus, linear algebra, and statistics. Such background and knowledge should have been obtained through the completion of the corresponding first-year courses.

Assignments will require the use of Python programming language, and the completion of the Intelligent Systems course is highly recommended.

Any experience with any modern procedural language (e.g. C++) should be sufficient in any case.

3. Justification in the curriculum, relation to other subjects and to the profession

This course will introduce students to the fundamental constraints, technologies, and algorithms of autonomous robotics. The focus will be on computational aspects of autonomous wheeled mobile robots. The most important themes will be mobility, perception, localization, and navigation. Assignments will require the implementation of behaviours suitable for being deployed in Mobile wheeled robots like the AWS Deep Racer car or the Pepper SoftBank Robotics Robot.

4. Degree competences achieved in this course

Course competences

Code	Description
CM02	Ability to know the theoretical fundamentals of programming languages, and their associated techniques for lexical, syntactic, and semantic processes, along with their application in the creation, design, and language processing.
CM04	Ability to know the fundamentals, paradigms, and techniques of intelligent systems, and analyse, design, and build systems, services, and digital, applications which could use such techniques in any application context.
CM07	Ability to know and develop computational learning techniques, and design and implement applications and systems which could use them, including the ones for the automatic extraction of information and knowledge from great batches of information.
INS04	Problem solving skills by the application of engineering techniques.
PER01	Team work abilities.
PER02	Ability to work in multidisciplinary teams.
PER03	Ability to work in an international context.
SIS03	Autonomous learning.
SIS08	Initiative and entrepreneurial abilities.
UCLM01	Command of a second language at a B1 level within the Common European Framework of Reference for Languages

5. Objectives or Learning Outcomes

Course learning outcomes

Description

Improvement of communication skills of the student in English language

Design and programming of basic and advanced behaviors that allow a robot to function autonomously in a specific environment.

6. Units / Contents

Unit 1: Introduction

- **Unit 1.1** Mobile Robots
- **Unit 1.2** Mobile Robot Architectures
- **Unit 1.3** Robot Behaviours

Unit 2: Mobility

- **Unit 2.1** Locomotion

Unit 3: Perception

- **Unit 3.1** Robot Sensing

Unit 3.2 Robot Vision
Unit 3.3 Advanced Perception

Unit 4: Localization

Unit 4.1 Introduction to localization
Unit 4.2 Markov Localization
Unit 4.3 Odometry motion model and Grid Localization
Unit 4.4 Monte Carlo Localization
Unit 4.5 Kalman filter localization methods

Unit 5: Advanced Topics

Unit 5.1 Simultaneous Localization and Mapping (SLAM)
Unit 5.2 Planning
Unit 5.3 Probabilistic Planning and Human Robot Interaction (HRI)

7. Activities, Units/Modules and Methodology

Training Activity	Methodology	Related Competences	ECTS	Hours	As	Com	Description
Class Attendance (theory) [ON-SITE]	Lectures	CM04 INS04 SIS03	0.42	10.5	N	-	Individual work activity
Laboratory practice or sessions [ON-SITE]	Practical or hands-on activities	CM02 CM04 CM07 INS04 PER01	0.9	22.5	Y	N	Group work activity
Study and Exam Preparation [OFF-SITE]	Self-study	CM04 INS04 SIS03	1.5	37.5	N	-	Individual work activity
Writing of reports or projects [OFF-SITE]	Self-study	CM04 INS04 PER01 PER02 PER03 SIS03 SIS08 UCLM01	0.9	22.5	N	-	Group work activity
Problem solving and/or case studies [ON-SITE]	Project/Problem Based Learning (PBL)	CM02 CM04 CM07 INS04 PER01	0.6	15	N	-	Individual work activity
Individual tutoring sessions [ON-SITE]	Lectures	CM02 CM04 CM07	0.18	4.5	N	-	Individual tutorig
Study and Exam Preparation [OFF-SITE]	Self-study	CM04 INS04 SIS03	1.2	30	N	-	Individual work activity
Formative Assessment [ON-SITE]	Assessment tests	CM02 CM04 CM07 PER01 SIS08 UCLM01	0.3	7.5	Y	Y	Tests
		Total:	**6**	**150**			
		Total credits of in-class work: 2.4					**Total class time hours: 60**
		Total credits of out of class work: 3.6					**Total hours of out of class work: 90**

As: Assessable training activity
Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System

Evaluation System	Continuous assessment	Non-continuous evaluation*	Description
Progress Tests	25.00%	40.00%	[PRES][ESC] - Continuous assessment: The evaluation of this activity is IN GROUPS Oral presentation in class and questions about a work already documented and submitted - Non-continuous evaluation The evaluation of this activity is INDIVIDUAL Theoretical test with multiple options
Theoretical papers assessment	15.00%	20.00%	[INF] - Continuous assessment / Non-continuous evaluation The evaluation of this activity is IN GROUPS Evaluation of a memory about a work previously submitted
Laboratory sessions	40.00%	40.00%	[LAB] - Continuous assessment / Non-continuous evaluation The evaluation of this activity is INDIVIDUAL Evaluation of the submissions resulting the from laboratory practices
Assessment of active participation	20.00%	0.00%	[PRES] - Continuous assessment: The evaluation of this activity is INDIVIDUAL Active participation during activities of relevan importance
Total:	**100.00%**	**100.00%**	

According to art. 6 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 13.2) to be globally graded, in 2 annual calls per subject , an ordinary and an extraordinary one (evaluating 100% of the competences).

Evaluation criteria for the final exam:

Continuous assessment:

Students will work individually in the laboratory sessions, with 4-6 submissions that will determine 40% of the final mark.
Students will work in groups on the documentation and presentation of a work related to some of the robotics topics presented during the theoretical lessons, and previously proposed by the teachers. The quality of the memory will determine 15% of the final mark. The oral presentation, defense, and overall quality will determine 25% of the final mark.

- 25% of the final mark will be set based on the oral presentation and defense of a team work
- 15% of the final mark will be set based on the memory of a team work
- 40% of the final mark will be set based on the individual laboratory asignments
- 20% of the final mark will be set based on the active participation of relevant activities like seminars, case studies or problem solving.

There are no restrictions about requesting a minimal mark in a given part to pass the course.

By default, the student will be evaluated by continuous evaluation. If you wish to change to non-continuous evaluation, you must indicate it through the following link https://www.esiiab.uclm.es/alumnos/evaluacion.php before the end of the term and as long as you have not submitted 50% or more of the subject by continuous evaluation.

Non-continuous evaluation:

Students will work individually in the laboratory sessions, with 4-6 submissions that will determine 40% of the final mark.
Students will work in groups on the documentation of a work related to some of the robotics topics presented during the theoretical lessons, and previously proposed by the teachers. The quality of the memory will determine 20% of the final mark.
There will be a progress theoretical test will multiple options that will determine 40% of the final mark

- 40% of the final mark will be set based on an individual theoretical test with multiple options.
- 20% of the final mark will be set based on the memory of a team work
- 40% of the final mark will be set based on the individual laboratory asignments

There are no restrictions about requesting a minimal mark in a given part to pass the course.

Specifications for the resit/retake exam:

The same criteria as for the non-continuous evaluation will be applied.

Specifications for the second resit / retake exam:

A written exam, covering all the theoretical and practical aspects of the subject, will determine 100% of the final mark.

9. Assignments, course calendar and important dates

Not related to the syllabus/contents

Hours	**hours**
Study and Exam Preparation [AUTÓNOMA][Self-study]	37.5
Writing of reports or projects [AUTÓNOMA][Self-study]	22.5
Individual tutoring sessions [PRESENCIAL][Lectures]	4.5
Study and Exam Preparation [AUTÓNOMA][Self-study]	30
Formative Assessment [PRESENCIAL][Assessment tests]	7.5

General comments about the planning: This course schedule is APPROXIMATE. It could vary throughout the academic course due to teaching needs, bank holidays, etc. A weekly schedule will be properly detailed and updated on the online platform (Virtual Campus). Note that all the lectures, practice sessions, exams and related activities performed in the bilingual groups will be entirely taught and assessed in English. Classes will be scheduled in 3 sessions of one hour and a half per week. The assessment activities could be performed in the afternoon, in case of necessity.

Unit 1 (de 5): Introduction

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	4.5
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4.5
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Unit 2 (de 5): Mobility

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	1.5
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4.5
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Unit 3 (de 5): Perception

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	1.5
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4.5
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Unit 4 (de 5): Localization

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	1.5
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4.5
Individual tutoring sessions [PRESENCIAL][Lectures]	3

Unit 5 (de 5): Advanced Topics

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	1.5
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4.5
Individual tutoring sessions [PRESENCIAL][Lectures]	3

Global activity

Activities	**hours**
Formative Assessment [PRESENCIAL][Assessment tests]	7.5
Individual tutoring sessions [PRESENCIAL][Lectures]	10.5
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	9
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	22.5
Study and Exam Preparation [AUTÓNOMA][Self-study]	37.5
Writing of reports or projects [AUTÓNOMA][Self-study]	22.5
Class Attendance (theory) [PRESENCIAL][Lectures]	10.5

Study and Exam Preparation [AUTÓNOMA][Self-study]	30	
	Total horas:	150

10. Bibliography and Sources

Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
Bekey, George A.	Autonomous robots : from biological inspiration to implement	The Mit Press		0-262-02578-7	2005	An introduction to the science and practice of autonomous robots that reviews over 300 current systems and examines the underlying technology.
Fahimi, Farbod	Autonomous robots : modeling, path planning, and control	Springer		978-0-387-09537-0	2009	Autonomous Robots: Modeling , Path Planning, and Control is suitable for mechanical and electrical engineers who want to familiarize themselves with methods of modeling/analysis/control that have been proven efficient through research. This book presents the theoretical tools for analyzing the dynamics of and controlling Autonomous Robots in a form comprehensible for students and engineers.
Niku, Saeed B. (Saeed Benjamin)	Introduction to robotics : analysis, control, applications	Wiley		978-0-470-60446-5	2010	Niku offers comprehensive, yet concise coverage of robotics that will appeal to engineers. Robotic applications are drawn from a wide variety of fields. Emphasis is placed on design along with analysis and modeling. Kinematics and dynamics are covered extensively in an accessible style. Vision systems are discussed in detail, which is a cutting-edge area in robotics. Engineers will also find a running design project that reinforces the concepts by having them apply what they've learned.
Thrun, Sebastian	Probabilistic robotics	The MIT Press		0-262-20162-3	2005	Probabilistic robotics is a new and growing area in robotics, concerned with perception and control in the face of uncertainty. Building on the field of mathematical statistics, probabilistic robotics endows robots with a new level of robustness in real-world situations. This book introduces the reader to a wealth of techniques and algorithms in the field. All algorithms are based on a single overarching mathematical foundation. Each chapter provides example implementations in pseudo code, detailed mathematical derivations, discussions from a practitioner's perspective, and extensive lists of exercises and class projects.
						It has long been the goal of engineers to develop tools that enhance our ability to do work, increase our quality of life, or perform

Frank L. Lewis, Shuzhi Sam Ge	Autonomous Mobile Robots: Sensing, Control, Decision Making and Applications	CRC Press	978-0367390891	2019	tasks that are either beyond our ability, too hazardous, or too tedious to be left to human efforts. Autonomous mobile robots are the culmination of decades of research and development, and their potential is seemingly unlimited.
Nikolaus Correll	Introduction to Autonomous Robots https://github.com/correll/Introduction-to-Autonomous-Robots	Magellan Scientific	978-0692700877	2020	This book introduces concepts in mobile, autonomous robotics to 3rd-4th year students in Computer Science or a related discipline. The book covers principles of robot motion, forward and inverse kinematics of robotic arms and simple wheeled platforms, perception, error propagation, localization and simultaneous localization and mapping. The cover picture shows a wind-up toy that is smart enough to not fall off a table just using intelligent mechanism design and illustrate the importance of the mechanism in designing intelligent, autonomous systems. This book is open source, open to contributions, and released under a creative common license.