Universidad de Alcalá

TEACHING GUIDE

Network Positioning Systems

Master's degree in Electronic Engineering

Universidad de Alcalá

Academic Year 2023/2024

TEACHING GUIDE

Name of subject:	**Network Positioning Systems**
Code:	**202943**
Degree taught:	**Master's degree in Electronic Engineering**
Departament and Area of Expertise:	**Departament:** Electronics **Area:** Electronic Technology
Character:	**Optional**
ECTS credits:	**4,5**
Course and semester:	**2nd Semester**
Teaching staff	**Check website UAH**
Office hours:	**Check website UAH**
Modality:	**Half face-to-face**
Language of teaching:	**Spanish**

1. COURSE SUMMARY

This course is optional, linked to the speciality Electronic Systems of Sensing and Control in Network.

The main objective of this course is to provide the student with the basic general knowledge about current positioning systems, with special emphasis on indoor environments, although outdoor ones will also be addressed.

To this end, the most common positioning techniques and algorithms will be studied, position errors will be analysed, systems will be calibrated and the different existing electronic technologies for the development of these systems will be detailed: radiofrequency, ultrasound, infrared and visible light. The most important applications will also be dealt with, as well as the peculiarities of network localization, evaluating cooperative localization.

2. SKILLS

This course contributes to the acquisition of the Basic, General and Specific Skills detailed below:

Basic Skills	
CB6	Get and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research contest.
CB7	Students should be able to apply their acquired knowledge and problem-solving skills in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.
CB8	Students should be able to integrate knowledge and deal with the complexity of making judgements on the basis of incomplete or limited information, including reflections on the social and ethical responsibilities linked to the application of their knowledge and judgements.
CB9	Students should be able to communicate their findings - and the ultimate knowledge and reasons behind them - to specialist and non-specialist audiences in a clear and unambiguous manner.
CB10	Students should get the learning skills to enable them to continue studying in a largely self-directed or autonomous manner.

General Skills	
CG1	Prepare concise, clear and reasoned documentation, specifying the work to be done for the development, integration and application of complex and high value-added electronic systems.
CG2	Acquire, assimilate and integrate autonomously advanced multidisciplinary concepts typical of Electronic Engineering, both in the research field and as a specialized professional.
CG3	Acquire skills in understanding new technologies for use in electronic systems and their appropriate use in solving new and partially defined problems.
CG4	Acquire teamwork skills to participate in research or technological projects in the field of Electronic Engineering.
CG5	Acquire the ability to transmit in a clear and unambiguous way, the concepts, developments and results, related to activities in Electronic Engineering, adapted to the profile of the audience.
CG6	Adopt the scientific method as a fundamental working tool to be applied both in the professional and research fields.

Specific Skills	
CE1	Ability to design electronic systems at a conceptual level based on specific specifications, at a system level using modelling and simulation tools, and at a subsystem level using hardware description languages among others.
CE2	Ability to know the properties of new analog, photonic and power electronic components (including new materials and structures), to improve the performance of current systems or applications
CE3	Ability to autonomously learn new tools, techniques and advanced methodologies for the design of electronic systems or subsystems.
CE4	Ability to design a device, system or application that meets given specifications, using a systemic and multidisciplinary approach and integrating the advanced modules and tools that are typical of the field of Electronic Engineering.
CE5	Ability to design, implement and manage a set of experimental tests and measures to assess the validity of innovative electronic proposals to partially defined problems.
CE6	Ability to participate in a multidisciplinary technical work team in the field of Electronic Engineering, with the capacity to react to technical and operational difficulties in the development of a technological project.
CE7	Ability to solve practical problems arising from the interaction of elements within an electronic system and with external agents, with effects such as signal interference, electromagnetic compatibility or thermal management, at the design, prefabrication and redesign stages.
CE8	Ability to identify merit factors and optimization techniques to address scientific and technological challenges in the field of Electronic Engineering and its applications.
CE9	Ability to propose indices of merit and apply optimization techniques for the development of electronic circuits and subsystems.
CE10	Ability to perform effective information searches to identify problems and propose solutions in the field of electronic and photonic systems.
CE11	Ability to know the current state of the art and future trends in the following areas: power electronics and control electronics.
CE12	Ability to identify from a conceptual but also practical point of view what are the main scientific and technological challenges in different applications of electronic systems, as well as in their integration and use.
CE13	Ability to plan the development of an electronic product, from the design phase to its preparation for marketing, complying with current regulations applicable to electronic systems in terms of electrical safety, electromagnetic compatibility and the environment.
CE14	Ability to carry out and defend before a university tribunal an original work that synthesises the competencies acquired in the teachings of the master's degree.

CE16	Ability to analyse and propose multidisciplinary and innovative solutions to complex problems related to electronic sensing and networked control systems.

On the other hand, the expected learning outcomes with this subject are as follows:

RAP1. To know specific systems of the speciality “electronic systems of sensing and control in network” related to the location.

RAP2. Apply the knowledge of the speciality to practical examples of location or positioning systems in the field of electronics.

3. CONTENTS

Content blocks (topics can be specified if necessary)	Total hours
Block 1. Theoretical issues	• **25 hours**
Topic 1. Introduction to location and positioning systems. Sensor networks, (2 hours)	
Topic 2. Positioning techniques and algorithms (8 hours) Overview of positioning techniques. Alternatives for obtaining position using angulation and latency. Relative positioning between nodes. Modeling of the position error. Strategies for calibrating positioning systems. Theory of probabilistic location.	
Topic 3. Positioning Technologies. (10 hours) Cameras. Infrared and visible technology. Acoustic systems. Radiofrequency. Inertial systems. Magnetic field. Signs of opportunity and infrastructure. GNSS.	
Topic 4. Network location and applications (5 hours) Introduction to network location. Methods for location in multi-agent systems. Cooperative localization. Alternatives for information exchange in a sensory network: time based, event based. Applications.	
Block 2. Laboratory practices	• **20 hours**
Practice 1. Development and simulation of algorithms for positioning (4h)	

Practice 2. Design and analysis of a positioning system based on coded ultrasonic signals (8h)	
Practice 3. Location techniques based on inertial sensors and their real practical application (4h)	
Practice 4. Study and analysis of a real location system based on radio frequency (4h)	
	45 hours

4. TEACHING METHOLOGIES-LEARNING ACTIVITIES

4.1. Credit distribution (specified in hours)

Number of hours:	22,5 h face-to-face or synchronous online 22,5 h online
Number of hours or personal work:	67,5 h
Total hours:	112,5 h

4.2. Methodological strategies, materials and resources

In the teaching-learning process, the following training activities will be carried out

Theoretical classes and problem solving	17,5 h
Theoretical-practical classes and practical classes in the laboratory	15 h
Tutorials sessions	12,5 h
Others: student work, virtual classroom activity and tests	67,5 h
Total hours	112,5 h

Throughout the course, students will be offered activities and tasks so that they can experience and consolidate the concepts acquired.

To carry out the practices, the student will have a place in the laboratory with a computer and the necessary elements for experimentation in the development of positioning systems.

During the whole learning process of the module, the student will have to make use of different sources and bibliographic or electronic resources, so that he/she gets familiar with the documentation environments that will be used in the research or professional field.

5. ASSESSMENT: Procedures, assessment criterio and grading system

Preferably, students will be offered a system of continuous assessment that has formative evaluation characteristics, so that it serves as feedback in the teaching-learning process by the student. To this end, the following are established.

5.1 Assessment procedures

The proposed evaluation process is inspired by the continuous assessment, although, respecting the rules of the University of Alcalá, the student will be able to benefit from the final assessment[1].

In order to evaluate the student, the following will be taken into account: the development of individual or group work, with its corresponding presentation in the classroom; the development of written tests, both open response and test-type; and the performance in carrying out the planned practices in the subject.

5.2. Assessment criteria

The Evaluation Criteria must consider the degree of acquisition of the skills by the student. To this end, the following are defined.

- CEv1: That the student knows the techniques and algorithms of positioning, as well as the peculiarities of network location.
- CEv2: That the student knows the different technologies used in the development of positioning systems.
- CEv3: The student will know how to apply the algorithms for the calculation of the position of mobile systems (robots, people, drones, etc.) and analyse their limitations.

[1] Students will have 15 days to request in writing to the Director of the Master their intention to use the final assessment model, giving the reasons they consider appropriate according to the regulations governing learning assessment processes (approved in Consejo de Gobierno, September 2021).

- CEv4: The student will be able to analyse and develop positioning systems using different electronic systems.
- CEv5: The student is able to generate correctly written, clear and precise documentation about the works proposed in the course.
- CEv6: The student presents and defends in a clear and reasoned way his/her proposals for the resolution of the problems proposed.

5.3. Grading instruments

The grading instruments to be applied are the following:

1. Test of basic knowledge consisting of a series of multiple-choice questions dealing with the basic theoretical aspects of the subjects taught.
2. Questions related to the design of localisation systems.
3. Development of individual or group work, which, in addition to writing the report, will be publicly presented in the classroom.
4. Laboratory practices, consisting of the development and analysis of different localisation systems.

The evaluation system of the acquired skills includes the following components:

Assessment of the theoretical block (PT) Written tests (PE) and objective tests (POT) Development of works (DeTr) and Presentation of works (ExTr)	 25% 25%	50%
Assessment of the practical block (PP) Four practices, weighted according to the work to be done.		50%

The overall grade of the course will be the weighted grade of each part, according to the indicated percentages.

5.4. Grading Criteria

5.4.1. Continuous Assessment Model

a) **Ordinary Call.** Students will be evaluated continuously by means of tests distributed throughout the school term. The percentages of weight of such tests on the final grade as well as the relation between the criteria and instruments of assessment of the subject are the following:

Learning outcomes	Assessment criteria	Grading instrument	Weight in the grading
RAP1, RAP2	CEv1, CEv2	PE + POT	25%
	CEv5	DeTr	15%

	CEv6	ExTr	10%
	CEv3, CEv4, CEv5	PP	50%

A student will be considered to have participated in the teaching-learning process and therefore **to have taken part in the ordinary call** if he or she takes one of the programmed tests of the theoretical part (PT) or the practical part (PP).

Students will be considered **to have passed the course** if they achieve an overall weighted mark of 5 or more (out of 10) out of all the grading instruments.

b) Extraordinary Call. Those students who do not pass the ordinary call will have the right to an extraordinary call. The theoretical part (PT) will be evaluated by means of an exercise with tests and questions, and the development of a specific work to be presented; and the practical part (PP) by means of a practical laboratory exam, in which the student must present the results of the tests carried out. In the case that in the ordinary call a student has passed any of the assessment tests (it is understood that a test has been passed if the previous qualification obtained is higher than 50%), the student will have the option of not repeating it in the extraordinary call. The percentages of weight of such tests on the final grade as well as the relation between the criteria, assessment instruments and the learning outcomes of the subject are as follows:

Learning outcomes	Assessment criteria	Grading instrument	Weight in the grading
RAP1, RAP2	CEv1, CEv2, CEv5	PE + POT	35%
	CEv5	DeTr	15%
	CEv6	ExTr	10%
	CEv3, CEv4, CEv5, CEv6	PP	50%

Students will be considered **to have passed the course** if they achieve an overall weighted grade of 5 (out of 10) or higher among all the grading instruments.

5.4.2. Final Assessment Model

Ordinary and Extraordinary call.

Students who opt for the final assessment system will be assessed as indicated in both the ordinary and extraordinary calls. The theoretical part (PT) will be evaluated by means of an exercise with tests and questions; and the practical part (PP) by means of a practical laboratory exam, in which the student must present the results of the tests carried out. The weight percentages of such tests on the final grade as

well as the relationship between the criteria, assessment instruments and the learning outcomes of the subject are as follows:

Learning outcomes	Assessment criteria	Grading instrument	Weight in the grading
RAP1, RAP2	CEv1, CEv2, CEv5	PE +POT	70%
	CEv3, CEv4, CEv6	PP	30%

Students will be considered **to have passed the course** if they achieve an overall weighted grade of 5 (out of 10) or higher among all the grading instruments.

6. BIBLIOGRAPHY

6.1 Basic bibliography

- Given the specificity of the subject, documentation prepared by the lecturers of the course will be provided for each of the topics covered.
- Technical articles selected for each topic.
- Handbook of Position Location, Theory, Practice and Advances, IEEE Press, Ed. Wiley, 2011
- Krzysztof W. Kolodziej, Johan Hjelm. Local Positioning Systems: LBS Applications and Services. Ed. CRC Press. Octubre 2006.
- Indoor Positioning Technologies. Rainer Mautz 2012
http://e-collection.library.ethz.ch/eserv/eth:5659/eth-5659-01.pdf

6.2 Additional bibliography

- Wellenhoff, Lichtenegger, and Collins, GPS Theory and Practice, Fifth Revised Edition, Springer Wien. 2001.
- Edgar H. Callaway, Jr. “Wireless Sensor Networks: Architectures and Protocols”. Ed. CRC Press. 2004.
- Pratap Misra y Per Enge. "Global positioning system. Signals, measurements and performance" Ganga-Jamuna Press.