Universidad de Alcalá

TEACHING GUIDE

Signal Processing Techniques for Intelligent Environments

Master in
Telecommunication Engineering

Universidad de Alcalá

Academic Year 2022/2023

2nd Year - 1st and 2nd Semester

Approved by the School Board on June 3, 2022

TEACHING GUIDE

Course Name:	**Signal Processing Techniques for Intelligent Environments**
Code:	**201827**
Master in:	**Telecommunication Engineering**
Department and area:	**Teoría de la Señal y Comunicaciones** **Teoría de la Señal y Comunicacicones**
Type:	**Optional (Specialized)**
ECTS Credits:	**6.0**
Year and semester:	**2nd Year, 1st and 2nd Semester**
Teachers:	Roberto Gil Pita (coord.) Saturnino Maldonado Bascón
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	Spanish / English Friendly

1. COURSE SUMMARY

This course approaches the main theoretical and practical concepts needed to implement final applications that will operate in intelligent environments. In particular, this course will offer the following knowledge to the students:

- Optimization techniques.
- Pattern Recognition.
- Artificial intelligence and deep learning for advances visual perception (object detection).

The main objective is that the student is able to understand the fundamental tools to create advanced solutions for intelligent transportation systems, space technologies or defense.

The main general competences this subject deals with are:

1. Acquire knowledge over advanced tools in signal processing, including artificial intelligence and pattern recognition techniques and their application to security, defense and logistics;
2. Capability to apply tracking, perception and navigation techniques to the guidance of unmanned autonomous vehicles (UAV);
3. Knowledge of strategies of route planning, logistic management of distribution centers, using heuristic methods and artificial intelligence.

We pay special attention to the establishment of these concepts in applications such as: computer-aided intelligent vision system, route management in logistic networks using soft-computing techniques.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/355/2009:

en_CB6 - To have and understand knowledges that provide a basis or opportunity to be original in the development and/or application of ideas, often in a research context

en_CB7 - That students know how to apply the acquired knowledge and problem-solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.

en_CB8 - That students be able to integrate knowledge and face the complexity of making judgements based on incomplete or limited information that includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgements.

en_CB9 - That students be able to communicate their findings and the ultimate knowledge and reasons behind them to specialized and non-specialized audiences in a clear and unambiguous manner.

en_CB10 - That students have the learning skills that will enable them to continue studying in a way that will be largely self-directed or autonomous.

en_CGT1 - Skill of analysis and synthesis.

en_CGT3 - Skill to analyze and search for information from diverse sources

en_CGT5 - Skill to adapt to new situations.

en_CT1 - Troubleshooting skill

en_CT6 - Ability to integrate knowledge from different scientific areas

Learning Outcomes

After succeeding in this subject the students will be able to:

RA1. Acquire knowledge about advanced tools in signal processing in intelligent environments, including techniques for optimization and pattern recognition, as well as its direct application for solving problems using scientific databases, and logistical planning problems for optimization of routes.

RA2. Ability to implement new solutions based on artificial intelligence techniques and deep learning, for security, defense and intelligent transport systems. Including the ability to incorporate new sensory devices in the infrastructures or in the vehicles or smart agents themselves.

RA3. Ability to design and evaluate, from a scientific perspective, those perception solutions for intelligent transport systems (e.g. autonomous vehicles, driving assistance systems or video surveillance systems), with special emphasis on artificial vision sensors.

RA4. Acquire the necessary skills for reading, studying and understanding scientific articles, with special attention to experimental evaluation procedures. Awareness of the open publication model.

3. CONTENTS

Contents Blocks	Total number of hours
Module 1: Engineering optimization techniques: Optimization problems with and without restrictions; Classic optimization algorithms: gradient descent and Newton method; Levenberg Marquardt method; Sequential Search methods; Modern heuristic optimization algorithms: genetic and evolutionary algorithms; Applications in optimization of transport systems.	12 hours
Module 2: Introduction to pattern recognition: Theory of learning. Classifiers based on Bayes decision theory; Linear and non-linear classifiers; Feature extraction; heuristic feature selection.	8 hours
Module 3: Classification methods: classification based on K-NN; Kernel methods; Linear and quadratic least squares discriminator; Neural networks of multilayer perceptron type (MLP); Radial base function networks (RBFN); Support Vector Machines (SVM); Decision trees and Random Forest (RF); Resolution of classification problems in scientific databases.	20 hours
Module 4: Artificial intelligence for visual perception in intelligent environments: Introduction to deep learning; Deep neural networks; Optimization of deep models: Backpropagation and Stochastic Gradient Descent. Convolutional Neural Networks for image recognition. Models of classification of images and detection of objects. Applications in security and intelligent transport: detection and tracking of objects.	20 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	60 hours
Number of hours of student work:	90
Total hours	150

4.2. Methodological strategies, teaching materials and resources

Magistral and expository classes, in combination with practices in the laboratory	In the expository sessions, the main concepts of the subject under study will be presented. The objective is to introduce the student to the theoretical foundations of the subject in a guided, sequential and reflective way. The assimilation of these concepts will culminate with the implementation of these in the laboratory, combining practice with theory in a unique work environment. The support with teaching materials will be fundamental to create reflective learning environments, where students and teachers can undertake a critical analysis that allows the student to relate concepts autonomously. The work sessions will be carried out mainly in small groups, in which the student can work as a team. The objective is that the student deepens on the theoretical knowledge of the subject and explore on the applicability of said knowledge
Seminars	Conferences and seminars constitute an element of teaching of great importance in postgraduate studies. As far as possible, conferences and seminars will be organized in the subject, offered by professors of recognized prestige both inside and outside the University of Alcalá.
Group and cooperative work	The objective is for the student to develop skills related to the search for information, the management of scientific literature and the production of reports and presentations on the topics proposed. In the same way, the aim is to encourage teamwork - groups of 2 students, coinciding with the work teams in the laboratory practices.
Work and personal study	Finally, the student's work and personal study is a key element in learning. The time dedicated to personal work should be, on average, twice as much as dedicated to face-to-face teaching, if you want to guarantee success in the subject. For personal study, the student should consult the recommended bibliography and the teaching material prepared by the teachers. The personal study should be aimed at understanding the theoretical concepts presented, and to acquire the ability to implement, in a practical way, systems based on them. The objective is for the student to develop skills related to the search for information, the management of bibliography and the making of reports on the topics proposed. In the same way, work is encouraged to encourage teamwork.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines (last modified in the Governing Board of October 31, 2019) as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary call

Students will be assessed by default according to the continuous assessment procedure in the ordinary call. To qualify for the evaluation by final exam, the student must request in writing to the dean or director of the center in the first two weeks of teaching the subject, explaining the reasons that prevent him from following the continuous assessment system. In the case of those students who, for justified reasons, do not have their registration formalized on the date of the beginning of the course or the period of delivery of the subject, the indicated term will begin to count from its incorporation into the degree. The dean or director of the center must assess the circumstances alleged by the student and make a motivated decision. After 15 working days without the student having received a written response to your request, it will be understood that it has been estimated.

Continuous assessment:

The content and timing of the Continuous Evaluation will be detailed at the beginning of each course in the Work Plan of the subject, which will include:

1. Realization of problems and work in small groups. Each group will be responsible for exposing the methods studied and solutions implemented for a set of problems and projects proposed by the teacher. Specifically, there will be two presentations or works: a) the first will address the contents of modules 2 and 3, focused on the analysis of pattern recognition solutions, in scientific databases; b) the second will focus on the study and presentation of a scientific article, related to the contents of module 4. For the contents of module 1, the evaluation will be addressed by solving problems.

2. Realization of laboratory practices and delivery of the corresponding memories and laboratory notebooks. The evaluation will consider the systematic observation, where the teacher will record the main difficulties and skills observed in each student, and the realization of a memory or laboratory notebook for practice, by each of the groups of students who have done it. Students must attend 100% of the laboratory sessions and deliver the corresponding reports to all laboratory practices. Recovery sessions will be enabled for those students who have not attended any of the sessions and justify it adequately.

   The students, as a group, will deliver the reports of the laboratory practices following the calendar established in the Work Plan of the subject. These practices will be evaluated by the professor responsible for the laboratory group, to check if the objectives indicated in the script of the same have been fulfilled.

Final exam assesment:

In the case of evaluation by means of a final exam, the evaluation elements to be used will be the following:

- Practical laboratory test.
- Theoretical-practical written test.

Students are recommended to perform laboratory practices during the development of the semester, thus replacing the practical laboratory test by the evaluation of the reports corresponding to the different practices.

Extraordinary call

The procedure will be the same as that described for the evaluation by means of a final exam in the ordinary call.

5.2. EVALUATION

EVALUATION CRITERIA

The following criteria will be used for the evaluation of the subject, related to the learning outcomes:

CE1. The student knows the basic heuristic optimization tools applied in intelligent environments.

CE2. The student has deepened in techniques of recognition of patterns of interest for applications in intelligent defense, security and transport environments.

CE3. The student has deepened in some of the applications related to intelligent environments and has successfully applied the techniques learned in class to the resolution of the specific problem.

CE4. The student knows the fundamentals of deep learning models for visual recognition applications, and their involvement in the intelligent processing of security, surveillance and defense environments.

RATING INSTRUMENTS

This section specifies the assessment instruments that will be applied to each of the evaluation criteria.

Partial Assessment (EP): Consistent in solving problems and practical exercises with the MATLAB computer tool about:

- EP1: Optimization systems.
- EP2: Pattern recognition tools.
- EP3: Deep learning models for visual recognition and detection and tracking of objects.

Essays of the subject (TA): The work of the subject consists of the realization of a theoretical-practical development deepening in the concepts described in the subject.

- TA1: Deepening optimization systems.
- TA2: Application of pattern recognition tools to a specific problem.
- TA3: Study, understanding and presentation of a scientific article about artificial intelligence and deep learning models. Special emphasis will be placed on the analysis of the results and the experimental evaluation.

Final exam (PEF): Consistent in the resolution of practical problems.

RATING CRITERIA

In the **ordinary call - continuous assessment** the relationship between the criteria, instruments and qualification is as follows.

Competence	Learning result	Evaluation criteria	Rating instrument	Grade weighting
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2	CE1	EP1	10,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2	CE2, CE3	EP2	20,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA3, RA4	CE4	EP3	20,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2	CE1	TA1	15,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2	CE2, CE3	TA2	20,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA3, RA4	CE3, CE4	TA3	15,0%

Students must achieve the minimum approved score independently in the laboratory and in the set of activities and tests related to the theoretical part of the subject (completion of work and final test). Taking this into account, in the case of continuous evaluation, the qualification will be made taking into account the following percentages and recitals:

- Work in small groups: 50%
- • Laboratory practices: 50%. Skills in the development of practices: 25%, Practice reports (average score of all of them): 25%

The qualification of "Not Submitted" will be awarded to the student who, having opted for the continuous assessment procedure, meets any of the following requirements:

1. When the student has broken the attendance at least 60% of the classes in small groups.
2. When the student has not delivered, at least 60% of the jobs requested.

When the student has exceeded the limits of attendance or delivery of work mentioned in the previous paragraph, regardless of their participation in the final exam, they will not be eligible for the grade of "Not Submitted".

In the **ordinary call - final evaluation**, the relationship between the criteria, instruments and qualification is as follows.

Competence	Learning result	Evaluation criteria	Rating instrument	Grade weighting
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2, RA3, RA4	CE1, CE2, CE3, CE4	PEF	100%

In the case of evaluation through a final exam, the grade will be taken taking into account the following percentages and contents:

- Practical laboratory test: 40%. The exam will consist in the realization of a practical test in the laboratory, where the acquisition of the practical competences of the subject is demonstrated.

If the students had made the laboratory practices and delivered the corresponding reports, 30% of the final grade will be the corresponding to the average grade of the reports and 10% to the skills in the development of the same.

- • Theoretical-practical written exam: 60%

Extraodrinary call

In the case of extraordinary calls, the same percentages that have been established in the case of the evaluation will be maintained by means of a final exam in the ordinary call, giving the option of carrying out the practical laboratory test or maintaining the grade obtained in laboratory practices. (continuous evaluation) or in the practical exam (final evaluation of the ordinary call), according to the student's decision.

Competence	Learning result	Evaluation criteria	Rating instrument	Grade weighting
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2	CE1	EP1	15,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2	CE2, CE3	EP2	25,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA3, RA4	CE3, CE4	EP3	20,0%
CB6-CB10; CGT1, CGT3, CGT5; CT1, CT6	RA1, RA2, RA3, RA4	CE1, CE2, CE3, CE4	PEF	40,0%

6. BIBLIOGRAPHY

6.1. Basic Bibliography

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6.2. Additional Bibliography

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- Pattern Recognition, Editorial Elsevier
- Pattern Recognition Letters, Editorial Elsevier
- IEEE Transactions on Pattern Analysis and Machine Intelligence, Editorial IEEE Press
- IEEE Transactions on Neural Networks, Editorial IEEE Press
- IEEE Communications Magazine

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.