Universidad de Alcalá

TEACHING GUIDE

Smart Control

Degree in
Industrial Electronics and Automatics Engineering

Universidad de Alcalá

Academic Year 2025/2026

4th Year - 2nd Semester

Approved by the EPS School Board on June 16th, 2025

TEACHING GUIDE

Course Name:	**Smart Control**
Code:	**600038**
Degree in:	**Industrial Electronics and Automatics Engineering**
Department and area:	**Automática** **Systems Engineering and Automation**
Type:	**Optional (Generic)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year, 2nd Semester**
Teachers:	Carlota Salinas Maldonado
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	Spanish/English Friendly

1. COURSE SUMMARY

Intelligent Control is an optional 6 ECTS subject included in the eighth semester – fourth year of the Degree in Industrial Electronics and Automation Engineering. The main goal is to study and understand the main ideas related with fuzzy and neural control systems. The basic concepts of this course are the next ones: principles of intelligent control, neural networks, neural system identification, neural control, fuzzy logic and fuzzy control. In addition, basic ideas of autonomous vehicle control will be presented by using The Open Racing Car Simulator (TORCS).

Prerequisites & Recommendations

For a good use of the subject, previous knowledge about fundamentals of physics, applied maths, MATLAB, C/C++ programming and Linux operating system are required.

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/351/2009:

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/351/2009:

Learning Outcomes

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

RACI1: to identify and recognise the main components of intelligent control systems.

RACI2: to identify and recognise the fundamental principles of neural networks and neural control.

RACI3: to identify and recognise the fundamental principles of fuzzy logic and fuzzy control.

RACI4: to identify and recognise the fundamental principles of adaptive neuro-fuzzy inference systems.

RACI5: to apply and implement neural network-based system identification methodologies.

RACI6: to design and implement solutions to control problems based on neural network control and fuzzy control methodologies.

3. CONTENTS

Contents Blocks	Total number of hours
Introduction to intelligent control systems	4 hours
Neural Networks	8 hours
Neural Control	4 hours
Neural Networks, System Identification and Neural Control with MATLAB	14 hours
Fuzzy Logic	6 hours
Fuzzy Control	4 hours
Design and simulation of fuzzy controllers with MATLAB	4 hours
Introduction to adaptive neuro-fuzzy systems (ANFIS)	2 hours
Design and simulation of ANFIS with MATLAB	2 hours
Design and simulation of a fuzzy-based controller to control an autonomous vehicle using racing simulator TORCS	8 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

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Theoretical sessions	Methodology: master classes where the teacher presents and explains the theoretical aspects, complemented by practical examples. Student participation will be encouraged from the theoretical concept developments, to the resolution of the proposed practical examples and the discussion of real cases. Resources: blackboard, audiovisual media, Internet, bibliography.
Practical problem solving sessions	Methodology: master classes of troubleshooting workshops combined with group and individual workshops. Small group discussion to reach the problem approaching and to look for the relation with theory. Written and oral presentation of alternative resolutions. Sharing of proposed resolutions. Resources: blackboard, audiovisual, bibliography.
Practical laboratory classes	Methodology: groups of 2 people maximum to work. Initial explanation and general discussion of the practice, collaborative work in each group with the teacher's guidance, management and good use of the material obtaining results, interpretation and presentation. Resources: blackboard, audiovisual, instrumentation and laboratory equipment.
Tutorials and seminars	Individual and/or group tutorials on the theoretical and practical subject contents.
Other type of activities	Troubleshooting and practices applying theoretic concepts, literature search, group work.

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 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

The evaluation in the ordinary call must be inspired by the continuous evaluation criteria (regulatory rules of the Teaching Learning Process, NRPEA, art 3), always attending to the acquisition of the competences specified in the subject:

Continuous Assessment:

Based on the accomplishment and passing the laboratory practices, the accomplishment of a mid-term tests, a lab tests and a final-term test.

The main assessment tools will be:

1. **Mid Term Exam (PEI)**: Practical and theory questions referred to the contents of both theory and laboratory classes.
2. **Development of Laboratory Practices (SL)**: Continuous assessment of practical work at the laboratory. The student behavior, interest, and motivation will be also taken into account. Completion of 5 proposed practical exercises, as well as classroom demonstration that the knowledge required to carry them out has been acquired. The student's attitude, interest, and participation will be taken into account. To assess the degree of completion of the practical exercises, the student must submit a report for each proposed practice, in which the results obtained and their analysis must be presented. The practical exercises are organized as follows
    a. Introduction to Neural Networks (MLP): working with MATLAB and solving exercises.
    b. Introduction to Convolutional Neural Networks (CNNs): design and implementation of CNN-based classifiers.
    c. Neural Control and System Identification: working with MATLAB and using MLPs for control and system identification.
    d. Fuzzy Logic: working with MATLAB and solving exercises.
    e. Fuzzy Control: design and implementation of Fuzzy based contollers.
3. **Global Laboratory Evaluation (PL)**: Final practical work related with the fuzzy controller applied to control an autonomous vehicle using the racing simulator TORCS, including an oral presentation and documentation. The performance of the provided solution will be also taken into account.

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 documentarily.

The students, as a group, will deliver the reports of the laboratory practices following the established schedule. These practices will be evaluated by the professor responsible for the laboratory group, to assess if the objectives indicated in the script of the same have been met.

Assessmen through final exam:

It will consist of the realization and passing of a final test. In order to stick for the final evaluation process, the student must notify it in writing to the dean of the center within the first two weeks of its incorporation, indicating the reasons that prevent the continuous assessment system. The dean of the center will communicate the resolution in a maximum of 15 days. In the case of lack of answer, this request is considered as estimated.

1. **Global Laboratory Evaluation (PL)**: Final practical work related with the fuzzy controller applied to control an autonomous vehicle using the racing simulator TORCS, including an oral presentation and documentation. The performance of the provided solution will be also taken into account.
2. **Final Exam (PEF)**: Practical and theory questions referred to the contents of both theory and laboratory classes.

Extraordinary Call

Students who have not passed the ordinary call will face a final test. The grade obtained in the laboratory practices and tests will be taken into account.

5.2. EVALUATION

EVALUATION CRITERIA

The evaluation criteria have to assess the acquisition level of the different skills by students. Accordingly, the following criteria are defined:

- **CE1**: The student shows ability and initiative to solve mathematical and practical problems related with neural networks and neural control.
- **CE2**: The student shows ability and initiative to solve mathematical and practical problems related with fuzzy logic and fuzzy control.
- **CE3**: The student shows ability and initiative to solve mathematical and practical problems related with system identification using neural networks.
- **CE4**: The student is capable of designing a fuzzy controller for an autonomous vehicle, to implement it, test and analyze the results.

GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

1. **Mid Term Exam (PEI)**: It will consist of various theoretical questions and practical problems related to specific aspects of the syllabus covered in the theory classes and laboratory sessions up to that point.
2. **Development of Laboratory Practices (SL)**: Continuous assessment of practical work at the laboratory. Completion of the 5 proposed practical exercises, as well as demonstrating in the classroom that the necessary knowledge to carry them out has been acquired. The student's attitude, interest, and participation will be taken into account. Each practice involves problems and exercises that the student must solve by applying the knowledge learned in theory. To assess the degree of completion of the practical exercises, the student must submit a report for each proposed practice. This report should contain the development carried out, the results obtained, and their analysis. Each practice carries the same weight, and together they constitute the total for this section
3. **Global Laboratory Evaluation (PL)**: Final practical work related with the fuzzy controller applied to control an autonomous vehicle using the racing simulator TORCS, including an oral presentation and documentation. The performance of the provided solution will be also taken into account.
4. **Final Exam (PEF)**: Practical and theory questions referred to the contents of both theory and laboratory classes.

GRADING CRITERIA

In the ordinary call-continuous assessment the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
	RACI1, RACI2	CE1	PEI	20%
	RACI1-RACI6	CE1-CE3	SL	40%
	RACI6	CE4	PL	20%
	RACI1-RACI6	CE1-CE3	PEF	20%

Students who do not participate in the continuous assessment will be marked as not presented. A student will be considered as absent if he or she does not attend the mid-term exam or does not attend the laboratory classes during the first four weeks.

The student will pass the continuous assessment if he or she obtains a global weight mark equal to or higher than 5 over 10.

The students that are not satisfied with the mark obtained in the mid-term exam (PEI), will have the opportunity to change this mark by carrying out an additional evaluation test that will take place after the final exam (PEF). This additional test will have the same weight as the mid-term exam (PEI).

In the ordinary call-final assessment the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
	RACI1-RACI6	CE1, CE2, CE3, CE4, CE5	PEF	100%

Extraordinary Call

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
	RACI1-RACI6	CE1, CE2, CE3, CE4, CE5	PEF	40/100% (*)

(*) For those students who have been following the continuous assessment in the ordinary call, the final weight of the final exam of the extraordinary call will be given by the following equation: max(PEF, 0.4PEF+0.4SL+0.2PL).

The teaching-learning methodology and the evaluation process will be adjusted when necessary, with the guidance of the Diversity Support Unit, to apply curricular adaptations for students with specific needs.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Lecture Notes elaborated by the teaching staff and provided via Blackboard.

6.2. Additional Bibliography

- Redes Neuronales y Sistemas Borrosos. Bonifacio Martín y Alfredo Sanz Molina. Ed. RAMA. 2001.
- A First Course in Fuzzi and Neural Control. Hung T. Nguyen et al. CRC Press. 2000.
- An Introduction to Fuzzy Control. D. Drankov, H. Hellendoorn and M. Reinfrank. Springer-Verlag.
- Neural Networks for Modelling and Control of Dynamic Systems. Ravn Norgaard, Hansen Poulsen, Springerâ€Verlag, 2000.

Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.