



## IDENTIFYING DATA

### Intelligent real-time systems

|                     |                                                                                                                                                                                                                                                                                                                   |          |      |            |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|------------|
| Subject             | Intelligent real-time systems                                                                                                                                                                                                                                                                                     |          |      |            |
| Code                | O06M193V01213                                                                                                                                                                                                                                                                                                     |          |      |            |
| Study programme     | Máster universitario en Inteligencia artificial                                                                                                                                                                                                                                                                   |          |      |            |
| Descriptors         | ECTS Credits                                                                                                                                                                                                                                                                                                      | Choose   | Year | Quadmester |
|                     | 3                                                                                                                                                                                                                                                                                                                 | Optional | 1st  | 2nd        |
| Teaching language   | English                                                                                                                                                                                                                                                                                                           |          |      |            |
| Department          |                                                                                                                                                                                                                                                                                                                   |          |      |            |
| Coordinator         | González Moreno, Juan Carlos                                                                                                                                                                                                                                                                                      |          |      |            |
| Lecturers           | González Moreno, Juan Carlos                                                                                                                                                                                                                                                                                      |          |      |            |
| E-mail              | jcmoreno@uvigo.es                                                                                                                                                                                                                                                                                                 |          |      |            |
| Web                 | <a href="http://https://moovi.uvigo.gal/">http://https://moovi.uvigo.gal/</a>                                                                                                                                                                                                                                     |          |      |            |
| General description | The main objective of this subject is to provide students with the minimum knowledge necessary for problem solving in the field of intelligent systems in real time, and the appropriate understanding of how to approach the resolution of these problems, but paying special attention to real time management. |          |      |            |

## Training and Learning Results

|      |                                                                                                                                                                                                                                                   |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                                                                                   |
| A1   | CB6 - Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context                                                                            |
| A2   | 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.                                       |
| A4   | CB9 - Students should be able to communicate their conclusions and the ultimate knowledge and rationale behind them to specialized and non-specialized audiences in a clear and unambiguous manner.                                               |
| A5   | CB10 - That students possess the learning skills that will enable them to continue studying in a manner that will be largely self-directed or autonomous.                                                                                         |
| B1   | Maintain and extend sound theoretical approaches to enable the introduction and exploitation of new and advanced technologies in the field of Artificial Intelligence.                                                                            |
| B2   | Successfully address all stages of an Artificial Intelligence project.                                                                                                                                                                            |
| B5   | Work in teams, especially multidisciplinary teams, and be skilled in time management, people management and decision making.                                                                                                                      |
| C19  | Knowledge of different application areas of AI-based technologies and their capacity to offer a differentiating added value.                                                                                                                      |
| C20  | Ability to combine and adapt different techniques, extrapolating knowledge between different fields of application.                                                                                                                               |
| C21  | Knowledge of techniques that facilitate the organization and management of AI projects in real environments, resource management and task planning in an efficient way, taking into account concepts of knowledge dissemination and open science. |
| C22  | Knowledge of techniques that facilitate the security of data, applications and communications and their implications in different AI application areas.                                                                                           |
| C30  | Be able to pose, model and solve problems requiring the application of artificial intelligence methods, techniques and technologies.                                                                                                              |
| D3   | Utilizar las herramientas básicas de las tecnologías de la información y las comunicaciones (TIC) necesarias para el ejercicio de su profesión y para el aprendizaje a lo largo de su vida.                                                       |
| D7   | Develop the ability to work in interdisciplinary or transdisciplinary teams to offer proposals that contribute to sustainable environmental, economic, political and social development.                                                          |
| D8   | Value the importance of research, innovation and technological development in the socioeconomic and cultural progress of society.                                                                                                                 |
| D9   | Have the ability to manage time and resources: develop plans, prioritize activities, identify critical ones, set deadlines and meet them.                                                                                                         |

| <b>Expected results from this subject</b>                                                                                                                     |                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Expected results from this subject                                                                                                                            | Training and Learning Results                                                 |
| RA1: Know the characteristics and functions of a real-time systems.                                                                                           | A1<br>A2<br>A4<br>B1<br>C20<br>D3<br>D8                                       |
| RA2: Ability to design and program a real-time system.                                                                                                        | A1<br>A2<br>A4<br>B1<br>B5<br>C20<br>D3<br>D7<br>D8                           |
| RA3: Know the most common programming languages for real-time systems, both synchronous and asynchronous.                                                     | A1<br>A2<br>A4<br>A5<br>B1<br>B5<br>C20<br>C21<br>D3<br>D7<br>D8<br>D9        |
| RA4: Know the production of reliable software components, with special attention to fault tolerance and error recovery.                                       | A1<br>A2<br>A4<br>A5<br>B1<br>B5<br>C20<br>C21<br>C22<br>D3<br>D7<br>D8<br>D9 |
| RA5: Know the basics of concurrent programming, communication and synchronization in real-time systems.                                                       | A2<br>A5<br>B2<br>C21<br>C22<br>C30<br>D7<br>D9                               |
| RA6: Know the temporal requirements of the functionalities of the language and the strategies to satisfy them, both in the synchronous and asynchronous case. | A1<br>A2<br>A4<br>A5<br>B1<br>B5<br>C20<br>C22<br>D3<br>D7<br>D8<br>D9        |

|                                                                                                                                                |                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| RA7: Know the architectures of integration of artificial intelligence in real-time systems, with a view to an efficient treatment of planning. | A4<br>A5<br>B1<br>B2<br>C19<br>C21<br>C30<br>D3<br>D8<br>D9 |
|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|

## Contents

| Topic                        |                                                                                                      |
|------------------------------|------------------------------------------------------------------------------------------------------|
| Real-time systems.           | Introduction.<br>RTS design.<br>Intelligent Systems in RT.                                           |
| Determinism and reliability. | Determinism.<br>Reliability.<br>Fault tolerance.<br>Exception handling.                              |
| Parallelism.                 | Concurrence.<br>Synchronous and asynchronous hypothesis.<br>Real time.<br>Planning.<br>Distribution. |
| Planning.                    | Strategies.<br>Verification of behavior.<br>Architectures.                                           |
| Implementation languages.    | General purpose languages.<br>Agent-based languages.<br>Simulation.                                  |

## Planning

|                        | Class hours | Hours outside the classroom | Total hours |
|------------------------|-------------|-----------------------------|-------------|
| Lecturing              | 12          | 12                          | 24          |
| Laboratory practical   | 8           | 24                          | 32          |
| Case studies           | 1           | 2                           | 3           |
| Project based learning | 0           | 16                          | 16          |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

|                      | Description                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lecturing            | Presentation by the teacher of the main contents of the subject.<br><br>CONTINUOUS ASSESSMENT<br>Mandatory character<br>Attendance: Mandatory<br>OVERALL ASSESSMENT<br>Mandatory character                                                                                                                                                                                                                   |
| Laboratory practical | Presentation and supervision by the teacher of practical problems that complement the theoretical contents seen in the master classes and in the presentations.<br><br>CONTINUOUS ASSESSMENT<br>Mandatory character<br>Attendance: Mandatory<br>OVERALL ASSESSMENT<br>Mandatory character                                                                                                                    |
| Case studies         | Teacher will present to Students a work scenario, real or fictitious, that exposes a certain problem. Students must solve it and present the solution through a video of about 10' in length; the solution will be elaborated by applying the knowledge acquired along the course.<br><br>CONTINUOUS ASSESSMENT<br>Mandatory character<br>Attendance: Mandatory<br>OVERALL ASSESSMENT<br>Mandatory character |

Project based learning The teacher will propose to the students a series of practical projects for their resolution using the contents seen both in theory and in the laboratory. The solution will be composed of an annotated code and a memory that adequately describes the solution provided.

#### CONTINUOUS ASSESSMENT

Mandatory character

Attendance: Mandatory

#### OVERALL ASSESSMENT

Mandatory character

### Personalized assistance

| Methodologies          | Description                                                                                                                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Case studies           | Teacher will advise the student on how to organize the contents chosen for exposure to the rest of the students. Teacher will use as support the telematic means available.                                |
| Project based learning | Teacher will advise the student on how to approach the design and organization of the solution proposed by the student to the assigned project. Teacher will use as support the telematic means available. |

### Assessment

|                        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Qualification | Training and Learning Results |          |                                 |                      |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------------|----------|---------------------------------|----------------------|
| Lecturing              | At the end of each topic, problems/exercises will be proposed that will be used for an evaluation through continuous monitoring of the subject. It allows the evaluation of RA1, RA3, RA4, RA5 and RA6<br><br>To release this assessment test, the student must get 5 points or more in their final grade.<br><br>In the case of opting for the global evaluation, on the date of the exam the students will be able to answer the exercises that are presented.                                                                                                                                                                                                                                                                                                   | 30            | A1                            | B1       | C19<br>C20<br>C21<br>C22<br>C30 |                      |
| Case studies           | Presentation of a video with its own solution to a proposed case study. It allows the evaluation of RA1, RA3, RA4, RA5, RA6 and RA7<br><br>This methodological test is compulsory, both in continuous and global evaluation.<br><br>To release this part of the evaluation, the student must get 5 points or more in their grade.<br><br>Late deliveries and those that are delivered in a different format than the order will be rated 0.                                                                                                                                                                                                                                                                                                                        | 30            | A4<br>A5                      | B1       | C19<br>C20<br>C21<br>C22<br>C30 | D8<br>D9             |
| Project based learning | The solution (code + explanatory memory) to a practical project proposed and assigned will be evaluated. It allows the evaluation of RA2, RA4, RA6, and RA7<br><br>This test will be evaluated with the applications provided to be carried out in groups of 2 people.<br><br>This methodological test is compulsory, both in continuous and global evaluation.<br><br>The delivery must be made on the dates and in the manner indicated. Late deliveries and those that are delivered in a different format than asked will be rated with 0.<br><br>The delivery could require a defense by the members of the group on the date and in the manner indicated.<br><br>To release this assessment test, the student must get 5 points or more in their final grade | 40            | A1<br>A2<br>A4<br>A5          | B2<br>B5 | C19<br>C20<br>C21<br>C22<br>C30 | D3<br>D7<br>D8<br>D9 |

### Other comments on the Evaluation

#### CONTINUOUS ASSESSMENT SYSTEM

#### TEST 1: Resolution of problems and/or exercises

Description: Resolution of exercises and/or problems proposed at the end of each topic to evaluate the comprehension of the unit and carry out continuous monitoring of the subject. These exercises will be carried out and delivered offline.

Methodology(s) applied(s): Lecturing.

Qualification: 30%

Minimum: For the release of this part of the subject, the student must obtain a grade equal to or greater than 5 points (out of 10) in the final grade of the test, which will be calculated cumulatively by adding the points achieved in each installment.

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## **TEST 2: Elaboration of Memory and Video**

Description: Preparation of a video and a brief report that presents/defends the student's solution to the assigned case study. The work will be developed in pairs and delivered offline on the date to be determined.

Methodology(s) applied: Case studies

Qualification: 30%

Minimum: For the release of this part of the subject, the student must obtain a score equal to or greater than 5 points (out of 10) in the evaluation of both the memory and the video. Late deliveries and those that do not meet the parameters set for delivery will be scored with 0 points.

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## **TEST 3: Development of a practice and a practice report**

Description: After the second week, a "Project" will be proposed to be developed and solved in pairs. The solution will evolve over the weeks with the support of laboratory classes in which doubts will be solved and the feasibility of the proposed solution will be continuously verified.

Methodology(s) applied: Project Based Learning

Qualification: 40%

Minimum: For the release of this part of the subject, the student must obtain a grade equal to or greater than 5 points (out of 10) in the evaluation, both in the code and in the report. Once the delivery has been made, a defense of the work carried out may be required in order to verify its authorship.

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- The final grade for the subject is calculated using the weighted average of the previous tests. In order to take said average, the student must achieve at least a 4 in each of the tests.
  - If, at the end of the course, a student presents a grade of less than 4, in two or more of the previous tests, his/her grade will be determined by the minimum value between the average of the grades and 4.
  - All the deliveries of the previous tests that are not carried out on time and in the requested form will be graded with a 0.

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## **GLOBAL EVALUATION SYSTEM**

Procedure for choosing the global assessment modality: Since the default assessment system is CONTINUOUS ASSESSMENT, it is considered that all enrolled students opt for said system. In case of wanting to be evaluated through the GLOBAL EVALUATION system, "Once the period of one month from the beginning of the semester has passed, a period of 5 working days will be enabled for the students enrolled in the subject to formally state their intention to benefit from the GLOBAL EVALUATION system"

### **TEST 1: Theory Exam**

Description: Objective test that will include the evaluation of the theoretical concepts seen throughout the course and resolution of exercises/problems proposed in the Continuous Assessment System.

Applied Methodology(s): Lecture

Qualification: 50%

Minimum: For the release of this part of the subject, the student must obtain a grade equal to or greater than 5 points (out of 10).

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## **TEST 2: Elaboration of Memory and Video**

Description: Preparation of a video and a brief memory that presents/defends the student's solution to a determined case study. The work will be delivered on the date determined prior to the final exam.

Methodology(s) applied: Case study

Qualification: 10%

Minimum: For the release of this part of the subject, the student must obtain a score equal to or greater than 5 points (out of 10) in the evaluation of both the memory and the video. A late delivery or one that does not conform to the parameters set for the delivery will be qualified with 0 points.

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## **TEST 2: Development of a practice and a practice report**

Description: Delivery of a solution to a "Project" that will be proposed for students who use this system and that must be delivered on the date (prior to the exam date) and in a manner determined. The solution will consist of a code with the solution and a report that explains and defends the proposed solution.

Methodology(s) applied: Project Based Learning

Qualification: 40%

Minimum: For the release of this part of the subject, the student must obtain a grade equal to or greater than 5 points (out of 10) in the evaluation, both in the code and in the report. Once the delivery has been made, the defense of the work carried out may be required in order to verify its authorship on the examination date by answering several questions related to the assigned "Project".

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- The final grade for the subject is calculated using the weighted average of the previous tests. In order to take said average, the student must achieve at least a 4 in each of the tests.
- If, at the end of the course, a student presents a grade of less than 4, in one or more of the previous tests, their grade will be determined by the minimum value between the average of the grades of said tests and four.
- All the deliveries of the previous tests that are not carried out on time and in the requested form will be graded with a 0.

## **EVALUATION CRITERIA FOR EXTRAORDINARY CALL AND FINAL DEGREE**

The continuous and global evaluation systems described above will be used.

## **RECORD QUALIFICATION PROCESS**

Regardless of the evaluation system and the call, if any part of the evaluation is not passed, but the overall score is greater than 4 (out of 10), the qualification in the minutes will be 4.

## **EVALUATION DATES**

The dates of the tests corresponding to the continuous assessment system will be published in the calendar of activities, available on the ESEI website <https://esei.uvigo.es/docencia/horarios/>.

The official exam dates of the different calls, officially approved by the Xunta de Centro of the ESEI, are published on the ESEI website <https://esei.uvigo.es/docencia/horarios/>.

## **USE OF MOBILE DEVICES**

All students are reminded of the prohibition of the use of mobile devices in exercises and practices, in compliance with article 13.2.d) of the University Student Statute, regarding the duties of university students, which establishes the duty to

"Refrain from using or cooperation in fraudulent procedures in the evaluation tests, in the works that are carried out or in official documents of the university."

## CONSULTATION/REQUEST FOR TUTORIALS

The tutorials can be consulted through the personal page of the teaching staff, accessible through <https://esei.uvigo.es/docencia/profesorado/>

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### Sources of information

#### Basic Bibliography

#### Complementary Bibliography

Alan Burns, Andy Wellings, **Sistemas de tiempo real y lenguajes de programación**, 9788478290581, 3ª, Addison-Wesley, 2003

Manuel I. Capel Tuñón, **Programación Concurrente y en tiempo real: Fundamentos y aplicaciones**, 9788417289362, Garceta, 2022

Rafael H. Bordini, Jomi Fred Hübner, Michael Wooldridge, **Programming Multi-agent systems in Agent-Speak with Jason**, 10.1002/9780470061848, Wiley, 2007

Olivier Boissier, Rafael H. Bordini, Jomi Hubner, Alessandro Ricci, **Multi-Agent Oriented Programming: Programming Multi-Agent Systems Using JaCaMo**, 9780262044578, MIT Press, 2020

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### Recommendations

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#### Subjects that it is recommended to have taken before

Multiagent systems/O06M193V01202

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