



## Teaching Guide

| Teaching Guide      |                                                                                                                                                                                                                                                                                                                                                  |        |          |                                    |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|------------------------------------|
| Identifying Data    |                                                                                                                                                                                                                                                                                                                                                  |        |          | 2022/23                            |
| Subject (*)         | Robotics                                                                                                                                                                                                                                                                                                                                         |        | Code     | 614G01098                          |
| Study programme     | Grao en Enxeñaría Informática                                                                                                                                                                                                                                                                                                                    |        |          |                                    |
| Descriptors         |                                                                                                                                                                                                                                                                                                                                                  |        |          |                                    |
| Cycle               | Period                                                                                                                                                                                                                                                                                                                                           | Year   | Type     | Credits                            |
| Graduate            | 2nd four-month period                                                                                                                                                                                                                                                                                                                            | Fourth | Optional | 6                                  |
| Language            | Spanish                                                                                                                                                                                                                                                                                                                                          |        |          |                                    |
| Teaching method     | Face-to-face                                                                                                                                                                                                                                                                                                                                     |        |          |                                    |
| Prerequisites       |                                                                                                                                                                                                                                                                                                                                                  |        |          |                                    |
| Department          | Ciencias da Computación e Tecnoloxías da InformaciónComputación                                                                                                                                                                                                                                                                                  |        |          |                                    |
| Coordinador         | Santos Reyes, Jose                                                                                                                                                                                                                                                                                                                               |        | E-mail   | jose.santos@udc.es                 |
| Lecturers           | Becerra Permuy, Jose Antonio                                                                                                                                                                                                                                                                                                                     |        | E-mail   | jose.antonio.becerra.permuy@udc.es |
|                     | Bellas Bouza, Francisco Javier                                                                                                                                                                                                                                                                                                                   |        |          | francisco.bellas@udc.es            |
|                     | Paz López, Alejandro                                                                                                                                                                                                                                                                                                                             |        |          | alejandro.paz.lopez@udc.es         |
|                     | Santos Reyes, Jose                                                                                                                                                                                                                                                                                                                               |        |          | jose.santos@udc.es                 |
| Web                 |                                                                                                                                                                                                                                                                                                                                                  |        |          |                                    |
| General description | This course is focused in the main concepts of autonomous robotics, emphasizing the automatic design of control strategies. The specific contents range from the classical control approaches to the newest based on computational intelligence principles, like artificial neural networks, evolutionary algorithms and reinforcement learning. |        |          |                                    |

## Study programme competences

| Code | Study programme competences                                                                                                                                                                                                                                                                                                        |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A43  | Capacidade para adquirir, obter, formalizar e representar o coñecemento humano nunha forma computable para a resolución de problemas mediante un sistema informático en calquera ámbito de aplicación, particularmente os relacionados con aspectos de computación, percepción e actuación en ambientes ou contornos intelixentes. |
| B1   | Capacidade de resolución de problemas                                                                                                                                                                                                                                                                                              |
| B3   | Capacidade de análise e síntese                                                                                                                                                                                                                                                                                                    |
| B9   | Capacidade para xerar novas ideas (creatividade)                                                                                                                                                                                                                                                                                   |
| C6   | Valorar criticamente o coñecemento, a tecnoloxía e a información dispoñible para resolver os problemas cos que deben enfrontarse.                                                                                                                                                                                                  |
| C8   | Valorar a importancia que ten a investigación, a innovación e o desenvolvemento tecnolóxico no avance socioeconómico e cultural da sociedade.                                                                                                                                                                                      |

## Learning outcomes

| Learning outcomes                                                                                  | Study programme competences |                |          |
|----------------------------------------------------------------------------------------------------|-----------------------------|----------------|----------|
| Develop an autonomous control system for its operation in a real environment                       | A43                         | B1             | C6       |
| Know the non-resolved problems in autonomous robotics                                              | A43                         | B1<br>B9       | C6<br>C8 |
| Know the problems of sensing and actuation in systems that operate in the real world and real time | A43                         | B1             | C6       |
| Know the problems of knowledge representation in autonomous robotics                               | A43                         | B1<br>B9       | C6       |
| Know the problems to tackle when an autonomous robotic control system is developed                 | A43                         | B1<br>B3<br>B9 | C6<br>C8 |

## Contents

| Topic | Sub-topic |
|-------|-----------|
|-------|-----------|



|                                     |                                                                                                                                 |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Introduction to autonomous robotics | ¿What is an autonomous robot?<br>History<br>Sensors and actuators<br>Behaviors<br>Planning<br>Learning and evolution            |
| Elements of a robotic system        | Robotic system<br>Actuators and effectors<br>Sensors<br>Control architectures                                                   |
| Behavior-based robotics             | Antecedents<br>Classical control architectures<br>Control architectures                                                         |
| Knowledge-based robotics            | Knowledge<br>Traditional deliberative robotics<br>Navigation                                                                    |
| Hybrid approximations               | Main hybrid architectures<br>Cognitive robotics                                                                                 |
| Evolutionary robotics               | Evolutionary algorithms<br>Application to robotics                                                                              |
| Learning in autonomous robotics     | Learning in classifier systems<br>Reinforcement learning: Q-learning<br>Combination of reinforcement and connectionist learning |

| Planning                                                                                                                        |                |                      |                               |             |
|---------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|-------------------------------|-------------|
| Methodologies / tests                                                                                                           | Competencies   | Ordinary class hours | Student's personal work hours | Total hours |
| Laboratory practice                                                                                                             | A43 B1 B9      | 21                   | 21                            | 42          |
| Supervised projects                                                                                                             | B1 B3 B9 C6 C8 | 0                    | 30                            | 30          |
| Guest lecture / keynote speech                                                                                                  | C6 C8          | 20                   | 20                            | 40          |
| Objective test                                                                                                                  | B3 C6          | 1                    | 0                             | 1           |
| Oral presentation                                                                                                               | B3 B9 C8       | 4                    | 28                            | 32          |
| Personalized attention                                                                                                          |                | 5                    | 0                             | 5           |
| (*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. |                |                      |                               |             |

| Methodologies                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Laboratory practice            | Lab. sessions in which the teachers will explain the robotic platform and its development software in detail. Moreover, in these programming exercises must be developed, using the selected robotic platform, some of the techniques taught in theory classes. These exercises will be carried out in an autonomous way and their progress will be supervised by the teachers.                                                                         |
| Supervised projects            | Theory work or works on a topic proposed by the teachers of the subject that must be developed by the students, individually or in groups, as determined by the teachers and with the indicated delivery dates. The most important work is the development (in a group) of a topic throughout the course, of which a final memory will have to be delivered, in addition to a final presentation (presentation that is part of the test or final exam). |
| Guest lecture / keynote speech | Oral presentation of the theoretical themes by the teachers of the subject.                                                                                                                                                                                                                                                                                                                                                                             |



|                   |                                                                                                                                                                                                                                                                                                        |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Objective test    | Multiple choice test or multiple choice questionnaire that is done online at the end of the theory sessions, in order to assess the degree of participation, attention and understanding of the concepts explained by the teacher. Moodle, Microsoft Forms, Kahoot or other similar tools can be used. |
| Oral presentation | Theory work or works on a topic proposed by the teachers of the subject that must be presented in front of the classmates and also delivered in writing.                                                                                                                                               |

## Personalized attention

| Methodologies                                                   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Oral presentation<br>Laboratory practice<br>Supervised projects | <p>During the lab practices and tutorials, the student can consult the teacher all the doubts that appear about the realization of the formulated practical problems or about the use of the simulator or the real robot.</p> <p>Supervised projects: It is recommendable the use of a personal assistance in these activities to resolve conceptual doubts or procedures than can appear during the resolution of the practical problems. Also, the personal assistance will be focused on in the explanation, by the student, of the proposed solution.</p> <p>Oral presentation: the students' progress in their theoretical work must be supervised by the teachers, both in terms of contents and format.</p> |

## Assessment

| Methodologies       | Competencies   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Qualification |
|---------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Oral presentation   | B3 B9 C8       | <p>The oral presentation of the theoretical work / papers proposed by the teachers is part of the final exam evaluation.</p> <p>It is necessary to obtain a passing grade in the sum of supervised projects+ oral presentation independently (minimum grade of 5 considering that it is valued from 0 to 10) in order to pass the course.</p>                                                                                                                                                                                                                                                                                                             | 20            |
| Laboratory practice | A43 B1 B9      | <p>One or more practices that will be carried out individually or in groups, as indicated by the teachers. They will span more than a week and may require additional work outside the classroom.</p> <p>It is necessary to obtain a pass grade in this methodology independently (minimum grade of 5 considering that it is valued from 0 to 10) in order to pass the course.</p>                                                                                                                                                                                                                                                                        | 50            |
| Supervised projects | B1 B3 B9 C6 C8 | <p>One or more theoretical works will be proposed throughout the course that will be developed autonomously, or in a group, by the student / group outside the classes and that must be defended before the teachers. The main work will be carried out in groups throughout the course, and a final report must be submitted. This work should be presented by the group in class, forming part of the evaluable oral presentation.</p> <p>It is necessary to obtain a passing grade in the sum of supervised projects+ oral presentation independently (minimum grade of 5 considering that it is valued from 0 to 10) in order to pass the course.</p> | 20            |
| Objective test      | B3 C6          | <p>The understanding of the concepts explained by the teacher in the master sessions implies that the students participate actively in the classes, raising doubts and making the most of personal interaction. This understanding is valued in the final grade of the subject through the online questionnaires that are carried out in the final minutes of each magisterial session.</p>                                                                                                                                                                                                                                                               | 10            |

## Assessment comments



The evaluation of this subject is based on the overcoming of the main methodologies (laboratory practices, supervised projects + oral presentation) independently. The first is focused on the practical demonstration of the knowledge and skills acquired to solve problems in autonomous robotics, and the second on the realization and presentation of works on a specific topic within the theoretical part. Thus, in the event that the student does not pass the subject in the ordinary period, they must repeat all the activities of the method/s that were not passed in the ordinary period. As an example, if a student approved the part of the supervised projects + oral presentation, but failed in laboratory practices, they should repeat the latter.

Students enrolled part-time in the subject

and those who choose to appear in the early call (December) must perform all methodologies except the objective test. The value of Supervised projects is added to that of laboratory practices, the latter becoming worth 60%. It is necessary for students to contact the teachers at the beginning of the semester to have adequate delivery margins.

In accordance with article 14, sections 1 and

3 of the regulations for the evaluation, review and claim of the qualifications of the university degree and master's degree studies, the latest version of which is dated June 29, 2017, the copy or attempted copy (or any improper behavior) during a test will imply the qualification of failure with a 0 in the two opportunities of the annual call.

According to article 14, section 4 of the

same regulations, plagiarism of any work will imply the qualification of failure with a 0 in that work.

## Sources of information

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b>         | <ul style="list-style-type: none"> <li>- Arkin, R.C. (1998). Behavior Based Robotics. MIT Press</li> <li>- Santos, J., Duro, R.J. (2005). Evolución Artificial y Robótica Autónoma. RA-MA</li> <li>- Mataric, Maja J. (2007). The Robotics Primer. MIT Press</li> <li>- Bekey, A. (2005). Autonomous Robots. MIT Press</li> </ul>                                                                                                                                                                                                                                                                                                                                            |
| <b>Complementary</b> | <ul style="list-style-type: none"> <li>- Pfeifer, R. and Scheier, C. (1999). Understanding Intelligence. MIT Press</li> <li>- Floreano, D. and Mattiussi, C. (2008). Bio-Inspired Artificial Intelligence. Tema 7. MIT Press</li> <li>- Nolfi, S., Floreano, D. (2000). Evolutionary Robotics. MIT Press</li> <li>- Santos, J. (2007). Vida Artificial. Realizaciones Computacionales. ServicioPublicaciones UDC</li> <li>- Salido, J. (2009). Cibernética aplicada. Robots educativos. Ra-Ma</li> <li>- Sutton, R.S., Burton A.G. (1998). Reinforcement Learning. MIT Press</li> <li>- Thurn, S., Burgard, W., Fox, D. (2005). Probabilistic Robotics. MIT Press</li> </ul> |

## Recommendations

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

Intelligent Systems/614G01020  
 Knowledge Representation and Automatic Reasoning/614G01036  
 Intelligent Systems Development/614G01037  
 Machine Learning/614G01038

### Subjects that are recommended to be taken simultaneously

### Subjects that continue the syllabus

### Other comments

To help achieve a sustainable environment and meet the objective of action number 5: Healthy and sustainable environmental and social teaching and research; Green Campus Ferrol Action Plan; the delivery of the documentary works carried out in this course:1. It will be requested in virtual format and/or computer support.2. It will be done through Moodle, in digital format without the need to print them.3. On paper:- Plastics will not be used;- Double-sided prints will be made.- Recycled paper will be used.- Draft printing will be avoided.



(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.