# Course guide
# 320044 - CGRM - Control and Guidance of Mobile Robots

**Last modified:** 02/04/2024

**Unit in charge:** Terrassa School of Industrial, Aerospace and Audiovisual Engineering
**Teaching unit:** 707 - ESAII - Department of Automatic Control.

**Degree:** BACHELOR'S DEGREE IN AUDIOVISUAL SYSTEMS ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN TEXTILE TECHNOLOGY AND DESIGN ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).

**Academic year:** 2024 **ECTS Credits:** 6.0 **Languages:** Catalan

## LECTURER

**Coordinating lecturer:** Masip Alvarez, Albert

**Others:** Perez Magrane, Ramon
Masip Alvarez, Albert

## PRIOR SKILLS

Knowledge of Control and Industrial Automation, Industrial Informatics, Modeling and Analysis of Dynamic Systems and Control Engineering.

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Specific:**
CE30. (ENG) ELO: Coneixements i capacitats per aprofundir en tecnologies específiques de l'àmbit.

## TEACHING METHODOLOGY

- Theoretical sessions.
- Sessions of practical work.
- Individual work
- Group activities and evaluation

## LEARNING OBJECTIVES OF THE SUBJECT

To apply control theory and technology in an integrated way with robotics and computing on mobile robots. The emphasis is mainly on how the practical aspects of control are applied on a real system, although its particularity, to get general experience.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours large group | 30,0 | 20.00 |
| Hours small group | 30,0 | 20.00 |
| Self study | 90,0 | 60.00 |

**Total learning time:** 150 h

## CONTENTS

### TOPIC 1: Mobile Robots

**Description:**
Sensors.
Actuators.
Hardware and Software Architecture.
The programming interface.

**Specific objectives:**
Description of the system to be controlled
Classify according to different characteristics
Recognize available elements: sensors and actuators
Describe the interface with the supervisor and the control architecture

**Related activities:**
All those described in the activity planning.

**Full-or-part-time:** 25h
Theory classes: 5h
Laboratory classes: 5h
Self study : 15h

### TOPIC 2: Wheel Control

**Description:**
Modeling, identification and simulation of wheel dynamics and kinematics.
Wheel angular speed control.

**Specific objectives:**
Describe the behaviour of the robot wheels using a physical model
Apply identification techniques to estimate model parameters
Design the wheel angular speed controller
Validate the control system

**Related activities:**
All those from the activity planning.

**Full-or-part-time:** 32h
Theory classes: 7h
Laboratory classes: 7h
Self study : 18h

**TOPIC 3: Computer vision oriented to control**

**Description:**
Image acquisition technology.
Camera modeling.
Vision techniques applied to automatic control.

**Specific objectives:**
Describe how an image is formed on a digital camera using the pinhole camera model.
Recognize the main parameters involved in the imaging processing and calculate the effect of any of them on the resulting images.
View and perform simple operations with black and white or color images in Matlab.
Represent 2D and 3D points and 2D straight lines with projective geometry.
Solve problems of translations and rotations of points in space and coordinate axes.
Calculate the effects of the main initial processing techniques and distinguish their effects.
Apply intensity filters to soften and contrast images, as well as detect contours.
Apply the simplest morphological operations to detect shapes in images.

**Related activities:**
All those described in the activity planning.

**Full-or-part-time:** 53h
Theory classes: 10h
Laboratory classes: 10h
Self study : 33h

**TOPIC 4: Trajectory control**

**Description:**
Modeling and simulation of robot kinematics.
Multivariable control.
Trajectory control.

**Specific objectives:**
Describe the behavior of the robot with a physical model.
Choose the most suitable multivariable control method for trajectory tracking.
Design and calculate the controller.
Validate trajectory control.

**Related activities:**
All those appearing in the activity planning.

**Full-or-part-time:** 40h
Theory classes: 8h
Laboratory classes: 8h
Self study : 24h

## ACTIVITIES

### EXAMS

**Description:**
There will be two written exams: one in the middle of the course (midterm exam) and the other at the end (final exam).
All the specific objectives of all the other activities that can be evaluated by means of a written exam are evaluated.

**Delivery:**
Written answer to a set of questions related to all contents and activities.
This activity contributes within 60% of the final mark corresponding to exams.

**Full-or-part-time:** 4h
Laboratory classes: 4h

### LECTURES

**Full-or-part-time:** 30h
Theory classes: 30h

### LABORATORY SESSIONS

**Full-or-part-time:** 26h
Laboratory classes: 26h

### SELF STUDY

**Full-or-part-time:** 90h
Self study: 90h

## GRADING SYSTEM

- Exams: 60 % (30% midterm exam, 30% final exam)
- Assessment during lab sessions: 40 %
The entire subject is included within the final exam in such a way that the grade of this final exam will replace that obtained in the first part if it is higher, in order to return the unsatisfactory results of the midterm exam. All students can take part in this modality.

## EXAMINATION RULES.

Students must attend and perform laboratory sessions.

## BIBLIOGRAPHY

**Basic:**
- Ballard, Dana H; Brown, Christopher M. Computer vision. Englewood Cliffs, NJ: Prentice-Hall, 1982. ISBN 0131653164.
- Siegwart, R.; Nourbakhsh, I.R.; Scaramuzza, D. Introduction to autonomous mobile robots [on line]. 2nd ed. Cambridge: MIT Press, 2011 [Consultation: 04/11/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=3339191. ISBN 9780262015356.

**Complementary:**

- González, R.C.; Woods, R.E.; Eddins, S.L. Digital image processing using Matlab. Upper Saddle River: Prentice Hall, 2004. ISBN 0130085197.
- Szeliski, Richard. Computer vision: algorithms and applications [on line]. London: Springer, 2011 [Consultation: 09/05/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=973471. ISBN 9781848829350.
- Muir, Patrick F.; Neuman, Charles P. "Kinematic modeling of wheeled mobile robots". Journal of robotic systems [on line]. Vol. 4, núm. 2 (1987), p. 281-340 [Consultation: 06/05/2020]. Available on: http://www.ri.cmu.edu/pub_files/pub3/muir_patrick_1986_1/muir_patrick_1986_1.pdf.- Ollero, A.; Heredia, G. "Stability analysis of mobile robot path tracking". 1995 IEEE/RSJ International Conference on Intelligent Robots and Systems 95. 'Human Robot Interaction and Cooperative Robots': proceedings [on line]. Vol. 3 (1995), p. 461-466 [Consultation: 09/05/2022]. Available on: https://ieeexplore-ieee-org.recursos.biblioteca.upc.edu/document/525925.