UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Last update: 23-07-2019

220072 - Advanced Control Systems

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control
Academic year: 2019
Degree: BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Bernardo Morcego

Others: Vicenç Puig

Prior skills

This course requires the student to have basic skills in:
Modelling of dynamic systems and transfer function
Control techniques (PID tuning)

Teaching methodology

The course is divided into parts:
Theory classes
Laboratory sessions
Self-study for doing exercises and activities.
In the theory classes, teachers will introduce the theoretical basis of the concepts, methods and results and illustrate them with examples appropriate to facilitate their understanding.
In the lab sessions, teachers guide students in applying theoretical concepts to solve problems, always using critical reasoning. We propose that students solve two autonomous robot control projects in and outside the classroom, to promote contact and use the basic tools needed to solve problems.
Students, independently, need to work on the materials provided by teachers in order to fix and assimilate the concepts.
The teachers provide the syllabus and monitoring of activities (by ATENEA).

Learning objectives of the subject

This course is about autonomous mobile robots as seen from the control point of view. The main types of mobile robots (ground, aerial and underwater) are reviewed and their common control architecture is presented. This architecture introduces four control problem categories which are examined (planning, navigation, perception and control). The course is about the control problems and the control tools to solve some of them.
One of the main objectives of the course is to acquire a hands-on experience, which will be obtained through the robotic control projects.
The principal tools of advanced control system design are introduced in the theory lectures and applied in the lab. These tools are the operational aspects of discrete control theory and the state space representation and analysis framework,

which allows the natural introduction of advanced control techniques, such as optimal control, model predictive control, etc.

Study load

Total learning time: 75h	Hours large group:	30h	40.00%
	Self study:	45h	60.00%

Content

Module 1: Mobile Robotics	Learning time: 33h Theory classes: 13h Self study : 20h

Description:
Mobile robots
Control architecture of autonomous mobile robots
Representative control problems

Related activities:
1, 2, 3

Specific objectives:
To classify and to describe the most usual types of mobile robots.
To arrange the information and decisions flow that autonomy imposes in the control of a mobile robot
Distinguish the control problems that need to be solved in an autonomous mobile robot

Module 2: Control Design	Learning time: 42h Theory classes: 17h Self study : 25h

Description:
Introduction to model-based control
Non-linear models and linearisation
Models for control: transfer functions and state-space representation
Controlability and observability
Controller design based on pole placement using transfer functions
Controller/observer design based on pole placement using the state-space representation
Relation between transfer function and state-space design
Controller/observer design based on optimization using the state-space representation

Related activities:
1, 2, 3

Specific objectives:
Design controllers with pole placement and optimization techniques.
Design observers with pole placement and optimization techniques.
Compare representation methods and select the most suitable to design controllers and observers.

Planning of activities

1. Theory lectures	Hours: 10h Theory classes: 10h

Description:
Exposition of the subject theory contents.

Support materials:
Slide compilations and handouts at Atenea
General bibliography of the subject

Specific objectives:
Knowledge transfer, creation of a conceptual reference frame, solving questions and generating interest about the subject.

2. Laboratory projects	Hours: 53h Theory classes: 18h Self study: 35h

Description:
Students, in groups, follow the instructions to resolve a practical control problem. These sessions take place at the lab and there are two problems to solve. Terrestrial and aerial mobile robots are the platforms used in the projects developed in the lab sessions.

Support materials:
Project instructions at Atenea
Simulation software (Matlab)
Lab plants (aerial and mobile robots)
Course handouts and notes

Descriptions of the assignments due and their relation to the assessment:
Each group has to deliver a report describing the results of the projects, the methodology and techniques applied to obtain the final results. A practical demonstrations is also required.

Specific objectives:
Proper application of control design methodology.

3. Final examination	Hours: 12h Theory classes: 2h Self study: 10h

Description:
Written individual examination about the concepts of theory modules. The examination includes conceptual questions, test questions, and problems to be solved by hand.

Support materials:
Examination instructions.

Descriptions of the assignments due and their relation to the assessment:
Answers to the questions and solutions to the problems posed in the instructions.

Specific objectives:
Assess the knowledge acquisition of activities 1, 2.
Distinguish from the group evaluation in activity 2.

Qualification system

Written individual examination: 34%
Project I assessment: 33%
Project II assessment: 33%
The students who do not pass the subject can take an additional global written exam that will take place the date stated in the calendar of final exams. The grade obtained in this exam will replace the one of the final exam in case it is higher. The maximum final mark in this case will be 5.0

Bibliography

Basic:

Franklin, G. F.; Powell, J. D.; Workman, M. L. Digital control of dynamic systems. 3rd ed. Menlo Park [etc.]: Addison-Wesley, 1998. ISBN 0201820544.

Brogan, William L. Modern control theory. 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, cop. 1991. ISBN 0135904153.

Ogata, Katsuhiko. Discrete-time control systems. Englewood Cliffs, NJ: Prentice-Hall, cop. 1987. ISBN 0132161028.

Aström, K. J.; Wittenmark, B. Computer controlled systems: theory and design. 3rd ed. Mineola, NY: Dover Publications, 2011. ISBN 9780486486130.

Siegwart, Roland; Nourbakhsh, Illah Reza; Scaramuzza, Davide. Introduction to autonomous mobile robots [on line]. 2nd ed. Cambridge: MIT Press, cop. 2011 [Consultation: 03/05/2019]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3339191>. ISBN 9780262015356.