MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

AUTOMATIC CONTROL
SSD ING-INF/04, 6 CFU

Objectives

The course aims at providing the following skills.

1) Knowledge and understanding:

Methodological tools for the design of modern and multi-variable control algorithms. Methodological tools for the design of control algorithms based on fuzzy rules, with the aim to handle ambiguity and to provide controllers that embody the knowledge of human experts.

2) Applying knowledge and understanding:

Ability to implement control algorithms, considering issues related to the use of computers or micro-controllers, and providing tools for the state reconstruction based on limited and uncertain information. Ability to implement fuzzy control algorithms.

3) Making judgements:

Ability to identify the most adequate control strategy, among those presented in the course, for solving complex problems such as the analysis and synthesis of control systems.

4) Communication skills:

Ability to communicate with the instructor and the other students with respect to complex topics such as control theory. Ability to formulate questions and to provide answers in english.

5) Learning skills:

The student will be guided in his learning process by means of a study methodology aimed at making productive the participation of the student to lessons and exercises. This will be obtained by the instructors via the participation and active involvement of the students during the lessons, since the student will have to solve problems with increasing degree of complexity during the course.

Prerequisites

Basilar elements of Control theory

Contents

The course is taught in English and it is composed of 4 units, detailed below.

1) Elements of digital control
Systems of linear difference equations with constant coefficients. Hybrid control schemes.
Sampling and reconstruction.
Aliasing and choice of the sampling time.
Basic notions on the Z transform.
Design of discrete-time controllers.
Implementation of digital control algorithms via computer and/or microcontroller.

2) State-space controI
Systems of linear differential equations with constant coefficients. State-space representation.
State feedback control.
Controllability.

State feedback with assignment of the dynamics.
Optimal control techniques: optimal problems, Pontryagin principle, optimal linear quadratic control, Riccati equation.
Implementation of state feedback control algorithms via computer and/or microcontroller.

3) Filtering and state reconstruction
Output feedback.
Observability.
State reconstruction via Luenberger observer.
Filtering and state reconstruction problems.
Kalman filter.
Extended Kalman filter.
Output feedback control schemes.
Implementation of filtering, estimation and output feedback control algorithms via computer and/or microcontroller.

4) Fuzzy Control

Introducton to soft-computing techniques with application to control. Principles of Fuzzy logic. Fuzzy Expert Systems: inferential engines, rules, Mamdami and Takagi-Sugeno-Kang systems. Fuzzy Control: fuzzy controllers in the control loop, fuzzyfication and defuzzyfication methods. Implementation of Fuzzy control algorithms via computer and/or microcontroller.

Teaching Methods

Lectures presenting the topics of the course (60%).
Exercises and tutorials, using the blackboard, computer and by means of Intel Galileo Gen 2, Arduino, or similar microcontrollers (40%).

Verification of learning

The design capabilities are assessed by means of a project work to be done in small groups (2-4 students). The project is related to the implementation of control algorithms in Matlab and/or on microcontrollers (Intel Galileo Gen 2, Arduino or similiar). The project work can be appointed by the teacher, but the students are encouraged to propose an original project to the teacher, who will evaluate the feasibility and adequacy. The comprehension of the topics of the course is assessed via a presentation that illustrates the project work and via an oral exam. The oral exam consists of two-three questions, which can be theoretical (e.g., demonstrations or presentation of the features of control schemes) or practical (e.g., exercises).

Texts

Handouts
Thomas Kailath, Linear Systems, Prentice-Hall, 1980.
Bonivento Melchiorri Zanasi, Sistemi di controllo digitale, Progetto Leonardo,1995
Additional Bibliography:
Passino, Kevin M., Stephen Yurkovich, and Michael Reinfrank. Fuzzy control. Vol. 42. Menlo Park, CA: Addison-wesley, 1998.
Franklin, Powell, Workman, Digital Control of Dynamic Systems, Addison-Wesley, 1998.
R. Setola, Tecniche di controllo a reazione di stato, dispense, 1997.
G. Marro, Controlli Automatici, Zanichelli, 2004.
Luenberger, Introduction to Dynamic Systems, John Weley & Sons, 1979. Bolzern, Scattolini, Schiavoni, Fondamenti di controlli automatici, McGraww- Hill, 2004.
Aderson, Moore, Optimal Control – Linear Quadratic Methods, Prentice-Hall, 1989.
Cavallo, Setola, Vasca, Guida operativa a Matlab Simulink e Control Toolbox, 1995.
Michael Margolis e B. Sansone, Arduino. Progetti e soluzioni, O'reilly, 2013