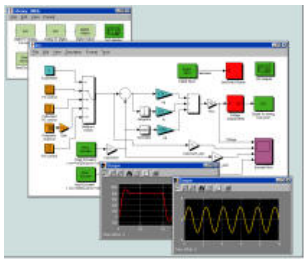

Control Laboratory

a.a. 2015-2016
Laurea Magistrale in Ingegneria dell'Automazione

Instructor and collaborators

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Description

Objecive of the course:
The goal of this course is to present to students all possible issues related to modeling and desing of advanced control systems via the implementation in a control laboratory of traditional control systems for industrial automation.
Synopsys:
Modeling of control systems: DC motor, DC motor with flexible joint. Representation of dynamical systems: state space, transfer fucntion, ODEs, impulse response. PID design in frequency domain. Anti-windup. Overview of state-space control design: state feedback, observers, separation principle, regulator design. Feedforward and Integral control. Internal model principle for periodic signal tracking. Discrete time dynamical systems: representation. Digital control and limits: quantization, samplying period, etc. Control design by emulation and by exact discretization. LQ control: formulation, theory and main results. Root locus of LQ control for SISO systems. Design of LQ weights. Extension of LQ control to frequency shaping. The tools presented in the lectures are asked to be implemented into a real CD motor provided with a flexible joint.

Lectures

Each lecture is provided with a link to textbook pages or PDF files.

WEEK	TUESDAY (10:30-12:15 room Ce)	WEDNESDAY (10:30-12:15 room Ee)	THURSDAY (12:30-14:15 room Le)	FRIDAY (12:30-16:15 Control Lab)
1 (1-3/03)	Introduction to the course (Lezione 1) **(Lecture 1)**	Overview of signal and systems. Representation o dynamical systems (Lezione 2) **(Lecture 2)**	Sensors and Actuators Modeling (Lezione 3) **(Lecture 3)**	
2 (8-10/03)	II order systems: representation and characteristics (Lezione 3) **(Lecture 4)**	Fundamental properties of control: disturbance rejection and model parameter sensitivity **(Lecture 5)**	**MATLAB and SIMULINK (laboratorio): Part I (Eng. Riccardo Antonello)**	
3 (15-17/03)	Approximation of (stable) dynamical systems with II order systems (Lezione 6) **(Lecture 6)**	**MATLAB and SIMULINK (laboratorio): Part II (Eng. Riccardo Antonello)**	**VISIT TO CONTROL LABORATORY (Eng. Riccardo Antonello)**	
4 (22-23/03)	Fundamentals of frequency domain desing: part II (Lezione 7) **(Lecture 7)**	PID Design **(Lecture 8)**	**NO LECTURE**	
5 (30-31/03)	**NO LECTURE**	Modeling of DC motor (Lezione 4) **(Lecture 9)**	PID configurations and anti-wind up (Lezione 8) **(Lecture 10)**	
6 (5-7/04)	Fundamentals of Moder Control Theory: reachability and controllability (Lezione 9) **(Lecture 11)**	State feedback control desing. Feedforward control (Lezione 10) **(Lecture 12)**	Integral control (Lezione 11) **(Lecture 13)**	**LAB 1: PID control design**

7 (12-14/04)	Internal model principle (Lezione 12) **(Lecture 14)**	Observers design. Regulators (Lezione 13) **(Lecture 15)**	Reduced order Observers & example **(Lecture 16)**	
8 (19-21/04)	Discrete time systems: representations (Lezione 14) Design via emulation (Lezione 15) **(Lecture 17)**	Exact discretization (Lezione 16) **(Lecture 18)**	Practical implementation of discrete time controllers **(Lecture 19 updated 6/5/16)**	**LAB 2: State-space control design**
9 (26-28/04)	Introduction to LQ control: Hamilton-Jacobi-Bellman and Riccati Equation (Lezione LC2 3) **(Lecture 20)**	LQ Control: solution of Riccati Equation via the Hamiltonian Matrix: Part I (Lezione LC2 4) **(Lecture 21)**	LQ Control: solution of Riccati Equation via the Hamiltonian Matrix: Part II (Lezione LC2 5) **(Lecture 22)**	
10 (3-5/05)	Properties of Hamiltonian Matrix (Lezione LC2 6) **(Lecture 23)**	LQ control: root locus (Lezione LC2 7, Lezione LC2 8) **(Lecture 24)**	LQ control: Weight design (Lezione LC2-10) **(Lecture 25)**	
11 (10-12/05)	Modeling of DC motor with flexible joint (Eng. Riccardo Antonello)	LQ control with frequency shaping (Lezione LC2-9) **(Lecture 26)**	Frequency shaping: examples (Lezione LC2-11 e Sez.6.7 in Note Controllo Ottimo LQ) **(Lecture 27)**	**LAB 3: digital control**
12 (17-19/05)	LQ control: robustness properties **(Lecture 28)**	Industrial guest lecture: SIEMENS	Industrial guest lecture: SALVAGNINI	
13 (26-28/05)				**LAB 4: LQ control** **LAB 5: extra lab (9/06 and 10/06)**

Material

1. Blackboard lectures
2. PID design in frequency domain [notes in PDF**]**
3. LQ control and Frequency Shaping [notes in PDF]
4. Guide for the laboratory software (MATLAB's Realtimeworshop toolbox) and hardware **[PDF]**
5. Notes on DC motor modeling, flexible joint modeling, segway modeling **[PDF]**
6. Notes on how to write a good technical report [PDF]

Laboratory experiments

1. Parameter identification and PID design for a DC electric motor
2. State-space control desing for a DC electric motor
3. Digital control desing for a DC electric motor
4. LQ control design for a DC electric motor with a flexible joint

Latex templates

1. Templates for Lecture notes
2. Templates for final Techicical report