Automatic Control and Robot Mechanisms
Second cycle course in Mechanical Engineering
12 (6+6) credits

The course is divided into two parts: automatic control and robot mechanisms. The first part offers to students knowledge and instruments for the analysis of dynamic mechanical systems, and for the project of the devices to control them. the second part will enable to analyze, modeling and project robotic systems.

First Part

Lecturer prof. Antonio Bicchi

Course Description

The course offers to students knowledge and instruments for the analysis of dynamic mechanical systems, and for the project of the devices to control them.The course is divided into two parts: automatic control and robot mechanisms.
The first part deals with control of linear systems, and the second with the control of non linear mechanical systems.
for the the a.a. 2007-2008 the second part is in common with the second course of Robotics (Robot control) – lecturer prof. Antonio Bicchi, second cycle course in Automation Engineering.

Course Objectives (Part I)

By the end of the course, students should be able to:
- analyze and control complex mechanical systems;
- evaluate the limits of application of the linear control methodologies in the case of non linear systems and to correctly use the instruments useful to overcome such limitations.
- read and understand the commercial devices used in the control of machines and mechanical systems, and to project control systems using such devices.
- know typologies and applications of the robotic systems used in industry and other service sectors

Lessons

During the lessons schematic notes will be projected and made available to the students online. Exercitations will be carried on by means of various informatics instruments (analysis and simulation software – MATLAB), available in faculty structures and of a telelab with real experiments available online without hour limitations.

Pre-requisites

Fundamentals of Automation.

Exam

First part: written and oral text.
During the written text the student has to solve one or more exercises. The use of course material and of every other useful material is allowed during the text, including the possibility of using commercial SW both for the project and simulation.
The oral text consists of one or more questions. The Examination Committee decides the final mark on the basis of all the elements collected during the two texts.
second part: oral text.
The final mark will be the average of the marks of both parts.

Course Contents (Part I) - Automatic control

1.Introduction.
Course presentation. Contro of linear systems obtained from non linear systems by linearization. Examples of limitations of classical control projecting (input-output)
2.Stability
Stability of a movement and of an equilibrium point. Simple and asymptotic stability. Stability of linear systems. Direct and indirect Lyapunov method. Lasalle and Krasovskii theorems. Limit cycles and invariant sets. Attractive domain of an equilibrium. Asymptotic global attractivity. Convergence speed. Lyapunov matrix equation and linear systems stability. Analysis of non linear system stability by means of linearization
3.Attainability and controllability
Stuctural properties of a dynamical system. Attainable set of time invariant linear systems.
Attainable matrix with respect to time (CR and DT).Attainability and changes of linear coordinates. Controllability to the origin. Optimal, pseudo inverse, Moore-Penrose planning and value matrix decomposition. Eigenvalue distribution in attainable and unattainable subspace of upgrade matrix of the state. Direct attainability verification. SISO systems attainability. P.B.H. Lemma. Canonic control form. Attainability of MIMO systems.
4.State feedback
Control of linear systems by means of state feedback. Invariance of attainability properties of a system with respect to state feedback. Fixed and variant eigenvalues of feedback. Eigenvalues allocation algorithms. Invariance of zeros of transmission. Multiple-input systems. Stabilizability of a linear system.
5. Observability and rebuildability
Observability of invariant linear systems with respect to time (CR and DT). Indistinguishable set with respect to time. Observability and change of linear coordinates. State rebuildability. Invariant subspaces and observability standard form. Optimal estimation. Observability of time- variant linear systems. Eigenvalue distribution in attainable and unattainable subspace of upgrade matrix of the state. Direct verifications of observability. Observability of SISO systems. P.B.H. observability Lemma. Observability canonical form. Kalman decomposition.
6.System regulation and output feedback.
Statistical output feedback. Dynamical output feedback. Asymptotic state observer. Realization of systems. Regulator.

Hours of explanation of new topics: 37
Hours of laboratory exercitations and examples: 18
Total: 55

Required reading

•P. Bolzern, R. Scattolini, N. Schiavoni: “Fondamenti di Controlli Automatici”, McGraw Hill
•E. Fornasini, G. Marchesini: “Appunti di Teoria dei Sistemi”
•Notes of the lecturer

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