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CICLO DI LEZIONI

Si comunica che nei giorni **6 e 7 Marzo 2001** presso la

Aula 5.2 - Facoltà di Ingegneria dell'Università di Bologna

il Prof. Arjan van der Schaft

dell'Università di Twente

terrà un ciclo di lezioni dal titolo

Modelling and Control of Physical Network Models

I Parte (6/3/01 - 14:30 - 17:30):
Geometrical formulation of network models of physical systems.

II Parte (7/3/01 - 9:30 - 12:30):
Control by interconnection and energy shaping.

III Parte (7/3/01 - 14:00 - 17:00):
Geometrical modelling and control of distributed parameter systems.

Abstract. In this talk a geometric framework for the modelling and control of physical systems is presented, which is based on a combination of the *network* and the *Hamiltonian* approach. Historically, the Hamiltonian approach has its roots in analytical mechanics and starts from the d'Alemberts principle towards the Hamiltonian equations of motion. On the other hand, the network approach stems from electrical engineering, and constitutes a cornerstone of systems theory. While most of the *analysis* of physical systems has been performed within the Lagrangian and Hamiltonian framework, the network modelling point of view is prevailing in *modelling* and *simulation* of (complex) physical systems. The talk involves joint work with (among others) B. Maschke and R. Ortega.
In **Part I** we shall present a model structure, called *port controlled Hamiltonian* (PCH) systems, which encompasses both the standard Hamiltonian systems as encountered in analytical mechanics, as well as the network type models arising in electrical, electromechanical and complex mechanical systems. The key feature is to associate with the interconnection structure of the network models a geometric structure called *Dirac structure*. With respect to such a Dirac structure an *implicit* Hamiltonian system with external variables may be defined. Dirac structures encompass symplectic forms and Poisson brackets, but they allow a considerable generalization since they also describe systems with *constraints* as arising from the interconnection of sub-systems. Dissipation may be included in PCH systems by terminating some of the ports by resistive elements.
In **Part II** we shall discuss the design of stabilizing controllers of physical systems modelled as PCH systems, directly exploiting the passivity properties and the (generalized) Hamiltonian structure of PCH systems, in particular the existence of Casimir functions. The advantages of using such a framework are thought to be manifold. It fits very well within the open-loop physical design of most technical systems based on the interconnection of subsystems corresponding to different functionalities, and allows an interpretation in similar terms of the controlled closed-loop system. Furthermore, the closed-loop system is expected to enjoy inherent robustness properties stemming from the physics of the system. The control design is based on *energy-shaping* (by state feedback or by interconnection with a dynamic controller), as well as on the *assignment* of the interconnection and damping structure matrices. Its potential will be illustrated by some examples from the area of mechanical, electrical and electro-mechanical systems.
In **Part III** we shall discuss how the the PCH description of actuated lumped-parameter systems can be extended to a geometric Hamiltonian formulation of *distributed parameter systems* with energy flow through the boundary of the spatial domain. Key concept is the notion of the (infinite-dimensional) Stokes-Dirac structure based on the conservation laws of the system. Examples that will be treated include (ideal) transmission lines, Maxwell's equations on a bounded domain, and fluid dynamics. Possibilities for boundary control design based on the PCH framework will be discussed.

Gli interessati sono caldamente invitati.

Prof. Claudio Melchiorri