کارگاه آموزشی رباتیک

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Passivity-based Control of Robotic Systems

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Abstract

Energy is one of the fundamental concepts in science and engineering practice, where it is common to view dynamical systems as energy transformation devices. This perspective is particularly useful in studying complex nonlinear systems by decomposing them into simpler subsystems which, upon interconnection, add up their energies to determine the full system's behavior. The action of a controller may be also understood in energy terms as another dynamical system typically implemented in a computer interconnected with the process to modify its behavior. The control problem can then be recast as finding a dynamical system and an interconnection pattern such that the overall energy function takes the desired form. This energy shaping" approach is the essence of the, now widely popular, controller design technique of passivity-based control (PBC), which was introduced by Ortega and Spong in 1989.

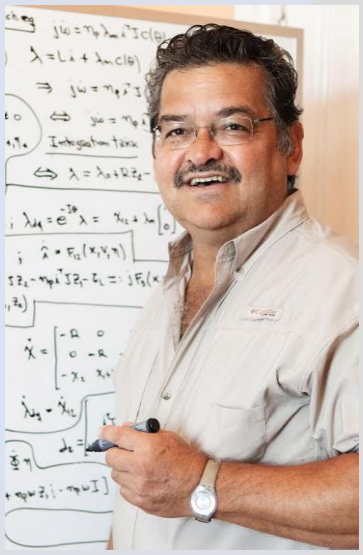
Stabilization of mechanical systems by shaping their energy function is a well established technique whose roots date back to the work of Lagrange and Legendre. Potential energy shaping for fully actuated mechanical systems was first introduced by Takegaki and Arimoto more than 30 years ago. To shape the potential energy for underactuated systems it is sometimes necessary to modify also its kinetic energy, a procedure that is called total energy shaping, which was first introduced by Ailon and Ortega in 1993. The last 25 years have witnessed an explosion of the use of PBC for the control of physical systems, in particular, mechanical ones.

Our objectives in this course are threefold. First, to call attention to the fact that PBC hinges on the fundamental (and universal) property of energy conservation, hence is (in principle) applicable to all physical systems. Second, to provide the basic tools for its utilization in the control of mechanical systems. Third, to briefly present the recent contributions to the field and identify the open questions.

Sunday, 26th of Farvardin (April 15)		
10:30-12:00	Kahroba Hall	Introduction and motivation
13:30-15:00	Kahroba Hall	Passivity, energy-shaping and stabilization
Monday, 27th of Farvardin (April 16)		
10:30-12:00	Kahroba Hall	Interconnection and damping assignment PBC of mechanical systems
13:30-15:00	Kahroba Hall	Recent results on PBC of mechanical systems and open issues

Biography

Romeo Ortega was born in Mexico. He obtained his BSc in Electrical and Mechanical Engineering from the National University of Mexico, Master of Engineering from Polytechnical Institute of Leningrad, USSR, and the Docteur D`Etat from the Politechnical Institute of Grenoble, France in 1974, 1978 and 1984, respectively.
He then joined the National University of Mexico, where he worked until 1989. He was a Visiting Professor at the University of Illinois in 1987-88 and at the McGill University in 1991-1992, and a Fellow of the Japan Society for Promotion of Science in 1990-1991. He has been a member of the French National Researcher Council (CNRS) since June 1992. Currently he is in the Laboratoire de Signaux et Systemes (SUPELEC) in Paris. His research interests are in the fields of nonlinear and adaptive control, with special emphasis on applications.
Dr Ortega has published three books and more than 250 scientific papers in international journals, with an h-index of 76. He has supervised more than 30 PhD thesis. He is a Fellow Member of the IEEE since 1999. He has served as chairman in several IFAC and IEEE committees and participated in various editorial boards of international journals.



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