Module Announcement

PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

Module Title: Introduction to modeling and control of mechanical systems with constraints

Lecturer: Prof. Anton Shiriaev

Norwegian University of Science and Technology

Department of Engineering Cybernetics

anton.shiriaev@ntnu.no

Telephone: +47 73590246

CV (max 500 characters.): A. Shiriaev received PhD in Applied Math from St. Petersburg State University, Russia, in 1997. Since 2009 he is professor at Dept. Engineering Cybernetics, NTNU, Norway. Dr. Shiriaev held permanent and visiting positions in Lund, Umea, Aalborg and Odense universities, the CNRS, the Tokyo Institute of Technology, Russian Academy of Sciences, University of Texas at Dallas. He published more than 150 papers in control theory and robotics subjects. His research activities have been supported by Research Councils of Sweden, Denmark, Norway.

Dates and Locations (rooms are in ed.1, via Claudio 21, Napoli)

Date	Hours	Room
July, 2nd 2018	**14.30-16.30**	**I.4**
July, 3rd 2018	**10:30-12:30**	**I.4**
July, 4th 2018	**10.30-12.30**	**I.4**
July, 5th 2018	**10.30-12.30**	**I.4**
July, 6th 2018	**10.30-12.30**	**I.4**

Summary

The course helps students systematically explore several topics and research directions in engineering, robotics and nonlinear control theory linked to efforts focused on developing scalable methods for performing and analyzing dynamically constrained systems. Modeling, motion planning and control methods for such systems become essential and unavoidable, for instance, in describing problem settings for automating various labor intensive tasks performed nowadays in industry and service applications. Most of dynamic constraints in applications are case specific or linked to scenarios of work of mechanisms. Constraints due to underactuation provide examples of generic structural features of nonlinear mechanical systems. They appear due to system designs and mean an excess of many degrees of freedom of the system over some actuators available in the system.

Module Announcement

The lectures provide introductory materials and problem settings to the subject exploiting generic arguments for modeling, representing and analyzing behaviors of nonlinear systems, which can be further extended and applied to controlled mechanical systems. The development is well illustrated by solving many comprehensive examples of increased complexity, where critical mathematical concepts and tools are emphasized and exemplified. The common thread of the lectures is put on the discussion of formalization of motion planning, stabilization, and stability analysis assignments and on the review of integrated approaches for solving the tasks, which are relevant to engineering applications and practice.

Content

I Lesson: Nonlinear dynamic systems. Concepts of stability of a motion. Stable cycles of nonlinear systems. Tools for analysis (Lyapunov lemma, Poincare first return map, small parameter and Krylov-Bogolyubov methods for approximate integration, Andronov theorem). Systems with dynamic constraints. Conceptual examples and assignments.

II Lesson: Nonlinear mechanical systems with constraints. Classification of constraints. Stability of nonlinear mechanical systems with constraints. Examples and solutions for several case studies (point mass dynamics subject to a honlonomic constraint and gravity; cart-pendulum; non-holonomic rolling coin, etc.).

III lesson: Problem formulations and settings for motion (trajectory) planning for constrained controlled mechanical systems. Examples and solutions for several case studies (underactuated ship; cart-pendulum forced by a constant force, etc.).

IV Lesson: Concepts of a motion generator (MG) and its dynamics for mechanical systems. A nested representation of motion candidates for underactuated mechanical systems. Properties of the dynamics of a MG derived based on the nested representation of a feasible behavior of an underactuated mechanical system. Examples of choices of MG and steps in planning feasible behaviors of several case studies (spherical pendulum; passive solid disc on a robot hand, etc.).

V Lesson: Concepts of transverse dynamics, moving Poincare sections, transverse coordinates and their linearization developed for controlling a motion of mechanical system.

ECTS Credits: 2

Notes

Doctoral Students are requested (starting from Lesson II) to bring their own notebook with Matlab installed. Assignments and homework assume developing models of dynamics for the case studies and realizing the arguments analytically and in simulations. By asking the lecturer the assignment of a small project to be solved before July, 13rd 2018, it is possible to obtain up to 1 extra credit. The project has the aim to apply the concepts and the tools assimilated during the module to a practical problem. Matlab software is needed to accomplish the assigned task. The lecturer is available at the department during the week from July, 9th to July, 13rd to provide support in solving the project.

Info: **Fabio Ruggiero, Ph.D. -** tel. 081 7683843 – fabio.ruggiero@unina.it