COURSE: Biorobotics

LECTURERS:

- Prof. Giorgio Metta : senior scientist @ Istituto Italiano di Tecnologia assistant professor @ DIST University of Genova.
- Prof. Francesco Nori: team leader @ Istituto Italiano di Tecnologia.
- Ing. Ugo Pattacini: PhD @ Istituto Italiano di Tecnologia .

Lecturers can be contacted via email name.surname@iit.it, e.g. francesco.nori(AT)iit.it. Appointments can be fixed during the entire week but needs to be arranged with the lecturer first.

COURSE RELATED INFORMATION

All the official communications regarding the course (cancelled lessons, scheduling of the exams, etc. etc.) are communicated on the mailing list (robotica(AT)liralab.it). Subscriptions to the mailing list are organized by Francesco Nori (francesco.nori(AT)iit.it); submissions can be posted here: http://courses.liralab.it/listinfo.

EXAMS GUIDELINES

Passing the exam requires successfully attending the classwork, which consists of two parts:

1. Practical part (24 points): typically 1 exercise consisting in computing the dynamic equation of a kinematic chain;
2. Theoretical part (6 points): typically 3 theoretical questions concerning the topics presented during the lectures.

The evaluation of the classwork is valid for one year. If the student attends more and one classwork, the valid classwork will be the last one.

EXAMS

Class-works are scheduled into three classes: ordinary, extraordinary and special sessions.

1. Ordinary class-works:
    a. 2 in the exam session February-March;
    b. 2 in the exam session June-July;
    c. 1 in the exam session September.
2. Extraordinary class-works: can be scheduled practically on demand during the entire year if there is a number of participants higher than 5.
3. Special class-works: for extremely particular needs, typically strict “laurea” or bureaucratic deadlines, it is possible to sustain an extraordinary classwork with less than 5 participants. These special class-works need to be scheduled with one of the lecturers.

TEXTBOOK

Unfortunately there is no textbook for the course. However, hand written notes concerning the material presented during the classes will be available on the course website (http://www.liralab.it/teaching/ROBOTICA/). The following textbooks cover part of the course program:

- "L. Sciavicco and B. Siciliano. Robotica Industriale. Modellistica e controllo di manipolatori, seconda edizione. McGraw-Hill. 2000. ISBN 88-386-0874-1",

Or the English version:

- "Modelling and Control of Robot Manipulators, 2nd Edition", ISBN/ISSN: 1-85233-221-2 , (2000) Springer-Verlag, London, UK".
- "A Mathematical Introduction to Robotic Manipulation" Richard M. Murray, Zexiang Li, S. Shankar Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, 1994.
- D. Kirk, Optimal Control Theory, Prentice-Hall, 1970.

PROGRAM

1. Calculus of variation for solving optimization functional optimization problems.
   1.1. Calculus of variations for solving the minimum jerk problem.
   1.2. Calculus of variations: theory and derivation of the Euler equations.
   1.3. Calculus of variations: optimal control problems.
   1.4. The Linear Regulator Problem.
   1.5. The Fixed-Final-State and Open-Loop Control. Derivation of the minimum-jerk trajectory as an optimal control problem.
2. Robot control for interaction with the environment.
   2.1. Compliance control.
   2.2. Impedance control.
   2.3. Hybrid position/force control.
3. Grasping.
   3.1. Grasp statics.
   3.2. Force closure.
   3.3. Grasp planning for achieving force closure.
   3.4. Differential kinematic grasping constraints.
4. Dynamic modeling of muscles.
   4.1. Muscle model and simulation, Jacobian of the muscle-limb system.
   4.2. Muscle model (spindle & Golgi tendon organs), limb stability, force field control.
5. Modeling human motion planning by means of stochastic optimal control.
   5.1. Stochastic dynamical systems
   5.2. State estimation by means of the classical Kalman filter.
   5.3. The Linear Quadratic Gaussian regulator (LQG).
   5.4. The generalization to nonlinear systems: the iLQG iterative algorithm (Todorov et al.).