PhD Program in Bioengineering and Robotics

Curriculum Advanced Robotics and Robotic Design - Italian Institute of technology

The Learning and Interaction Lab, Department of Advanced Robotics, Italian Institute of Technology (IIT) has a number of PhD openings in the field of machine learning and human-robot interaction. The positions are fully funded, start in January 2014 and typically last 3 years. IIT is an English-language research institute located in Genoa, Italy, a seaside Mediterranean city set on the beautiful Italian Riviera, where the cost of living is much more affordable than many other European cities.
Full details of the Call, application procedure and links (including a useful *tip&tricks* page) can be found at:
`http://www.iit.it/phdschool`
`http://programming-by-demonstration.org`

Application requirements:

Strongly motivated candidates holding a Master degree in Computer Science / Engineering / Mathematics or other related fields are invited to apply. Applicants should ideally have a background in machine learning, robotics or human-robot interaction, with strong mathematical and computer programming skills (Matlab, C++ or equivalent).

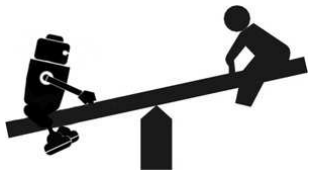
Application procedure:

The application procedure is described on: `http://www.iit.it/phdschool`. Prior to the deadline, the applicants should additionally send a detailed CV, statement of motivation, BSc and MSc transcripts, degree certificates and other support material such as reference letters to Dr Sylvain Calinon (`sylvain.calinon@iit.it`).

Research themes for 2014:

These research themes are officially listed in the category **BIOENGINEERING AND ROBOTICS: Curriculum Advanced Robotics and Robot Design**.

Theme 10 - Human-robot collaborative manipulation and coordination in bimanual tasks



The recent introduction of compliant robots into the robotics market has opened up a host of new human-centric research possibilities in robot learning. Because robots are no longer put behind fences (as in large manufacturing plants), they are increasingly capable of executing tasks in collaboration with human users. Such human-robot collaboration requires drastic changes in the way robots skills are represented, with the way they move, learn, react, and physically interact with the users and environment.

The perspective is to go beyond reference trajectory tracking control by exploiting the active and/or intrinsic compliance of bimanual robots. With the fast development of these new robot technologies, one key element for robot learning by imitation and exploration is to flexibly encode the learned skills in parsimonious probabilistic models. The aim is to guarantee generalization and adaptation, while handling the growth in the number of actuators and sensors. The principle of reducing the complexity of a nonlinear trajectory by encoding it as a superposition of simple local motion elements (or movement primitives) will be extended to concepts such as impedance primitives or synergy primitives. This PhD proposal will address research themes related to the problem of transferring bimanual collaborative manipulation skills to robots in a user-friendly manner. Such skills involve rich and diverse research questions such as passive/active roles switching, leader/follower behaviors, specialization, turn-taking, compliance, inter-agent synchronization, action anticipation, intention recognition in joint action and the use of non-verbal cues to communicate intent. These issues will be studied in two contexts: 1) with bidirectional social teaching interaction with the compliant humanoid robot COMAN; 2) within an manufacturing scenario with an innovative setup based on two 7 DOFs compliant manipulators with sensorized hands.
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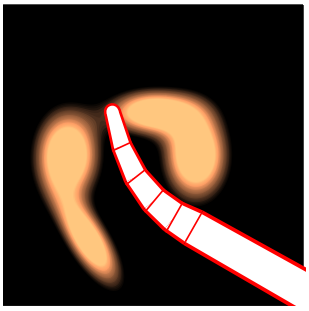
Theme 11 - Learning from demonstration in a soft robotic arm for assistance in minimally invasive surgery



This PhD proposal takes place within the STIFF-FLOP project (STIFFness controllable Flexible and Learn-able Manipulator for surgical OPerations), a project in collaboration with 11 universities, research institutes and companies in Europe. The aim is to transfer skills from a surgeon teleoperator to a flexible robot that can selectively stiffen its body to navigate within the patient through a trocar port. In minimally invasive surgery, tools go through narrow openings and manipulate soft organs that can move, deform, or change stiffness. There are limitations in current robot-assisted surgical systems due to the rigidity of robot tools.

A soft robotic arm is developed within the project to manipulate objects while controlling the stiffness of selected body parts. This form of *continuum robot* is inspired by the way the octopus makes use of its embodiment to achieve skillful movements. This PhD proposal will focus on the learning and human-robot interaction aspects.

The proposal will address the problem of representing movements and reactive behaviors in continuum robots (or invertebrates), by handling both the continuity of the movement and the continuity of the robot with statistical dynamical systems. The objective is to extract relevant patterns from consecutive trials to learn force/position control manoeuvres so that the teleoperator can, over time, concentrate on high level decisions while the robot takes care of low level reactive manoeuvres. The learning problem will be studied in tight connection with the control problem to orchestrate the degrees of coupling of the flexible arm that best suit the statistics of the task (e.g., by stiffening the arm in task relevant dimensions).

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Theme 12 - Bidirectional user interfaces for human-robot interaction

Research in robot learning can benefit from user interfaces technologies originally developed for mobile communication and video games applications. These developments can provide new ways of sensing the environment and interacting with the user in robotics, usually provided at low cost. Currently, a popular trend in this direction is to exploit structured light field of infrared beams (such as Kinect) and stereoscopic vision arrangement (such as Leap Motion) to measure depth information at various ranges of distance. There are also other uprising technologies such as the use of lightweight pico-projector that can be used to project information in the workspace shared by the user and the robot.

While a fixed camera/projector system has a static field of view, embedding these devices at the tip of a robot opens up a host of new possible applications, in which the devices can move and project/detect from various viewpoints and angles. For example, the robot can actively reconfigure the sensing and projecting directions in regard to the task constraints, by projecting information on relevant objects or surfaces in the workspace, and by adapting the distance and orientation with respect to the specificities of the collaborative task and to the possible occlusion of the user, tools, etc. Such configuration also offers adaptive multiresolution tracking and projection features (the detection of users in the surroundings requires a different field of view than the detection of precise positions of objects close to the robot).

This PhD proposal will address the challenge of exploiting these new technologies as user-friendly interfaces to facilitate the communication and transfer of new skills to robots.

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