Open PhD positions - Learning & Interaction Lab
Department of Advanced Robotics, 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 2013 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. International applications are encouraged and will receive logistic support with visa issues.

For more information: http://programming-by-demonstration.org/PhD-positions-2013.php
Application website: http://www.studenti.unige.it/postlaurea/dottorati/xxviiiciclo/IITen
Application deadline: **September 21, 2012** (12 noon, Italian time)

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: To apply please 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). The applicants also need to fill the online application procedure from the University of Genova: http://www.studenti.unige.it/postlaurea/dottorati/xxviiiciclo/IITen.

The following research topics are available:

STREAM 1: Machine Learning, Robot Control and Human-Robot Interaction (Advanced Robotics Prof. Darwin Caldwell)

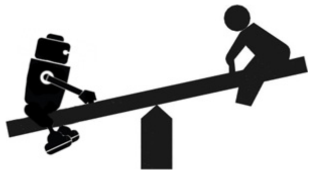
Theme 3.2 - Dextrous manipulation learning with bimanual compliant robots

Robotic systems get increasingly complex with the fast development of new hardware and sensing technologies, not only with respect to the number of motors and sensors, but also with respect to the new actuation/perception modalities that will be endowed in Tomorrow's robots. One such new perspective is to go beyond reference trajectory tracking control by exploiting active and/or intrinsic compliance capabilities of the robots. Such perspective requires us to redefine the machine learning problems towards a flexible regulation of stiffness and damping behaviors. With the fast development and expected widespread use of these new robot technologies, one key element for robot learning by imitation and exploration is to flexibly encode the learned skills with a minimum number of efficient control variables. The aim is to guarantee generalization and adaptation capabilities while avoiding to grow with the number of articulations or sensory modalities, in order to ensure real-time adaptive behavior.

The problem of bimanual coordination in such new settings needs to be thoroughly revisited. This PhD proposal will address research themes such as learning and adaptation of local sensory-motor activity couplings. The principle of reducing the complexity of a non-linear trajectory by representing it as a superposition of simple local motion elements (or movement primitives) will be extended to concepts such as impedance primitives or synergy primitives.
The role of haptics in dextrous manipulation skill acquisition will be explored in the context of bidirectional social teaching interaction with the compliant full humanoid robot COMAN, as well as in an industrial context with an innovative cooperative manufacturing setup based on two 7 DOFs compliant manipulators with sensorized hands.

Theme 3.3 - From human-human to human-robot collaborative skills acquisition

The recent introduction of robots with compliant capabilities into the robotics market has opened up a host of new, human-centric research possibilities, for scientists working in the fields of robot learning and social robotics. Two examples include kinesthetic teaching and human-robot cooperation. Because robots are no longer "put behind fences", they are increasingly capable of executing tasks in collaboration with human users. Such human-robot collaboration requires engineers to make drastic changes in the way robots move, learn and interact with users.

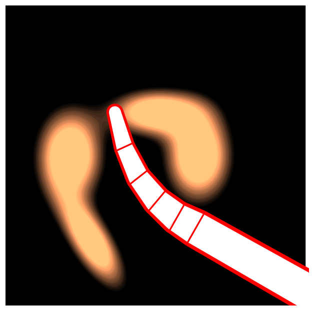


This PhD proposal addresses the problem of transferring collaborative manipulation skills to robots in a user-friendly manner. Such skills involve rich and diverse behaviors such as the assignment of leader/follower behaviors, passive/active roles switching, specialization, turn-taking, compliance, inter-agent synchronization, action anticipation, and the use of non-verbal cues to communicate intent.
There are clear limitations to engineering solutions currently being used to implement such skills in robots. Critically, these skills sometimes appear to us as naturally grounded. It is proposed to study how versatile robotic peers could be developed, by looking at human-human collaboration to gain a better understanding of the mechanisms supporting the acquisition of collaborative manipulation skills.
The neurocognitive mechanisms supporting human-human cooperation will be studied in collaboration with Prof. Roger Newman-Norlund, Director of the Division of Motor Control and Rehabilitation at the University of South Carolina. The nature and roles of mutual responsiveness, complementary action, intention recognition and empathy in joint action will be studied from behavioral, psychological and cognitive neuroscience perspectives, by considering the performance of human-human dyads comprised of healthy subjects and subjects with impaired social abilities (i.e. Autism).
The human-robot cooperation experiments will be conducted with the compliant full humanoid robot COMAN, as well as with two 7 DOFs compliant manipulators with sensorized hands.

Theme 3.4 - Learning from demonstrations 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), which is a collaboration with 11 universities, research institutes and companies in Europe (KCL, UK, SSSA, Italy, TRI, Spain, PIAP, Poland, HUJI, Israel, UoS, UK, USiegen, Germany, Shadow, UK, FRK, Poland and EAES, Netherlands).

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 will be available within the project to manipulate objects while controlling the stiffness of selected body parts. This PhD proposal will focus on the learning, human-robot interaction and variable compliance manipulation aspects.



The objective is to exploit the relevant statistical information contained in multiple demonstrations from the teleoperator 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 control manoeuvres in a semi-autonomous fashion. The PhD candidate will conduct robotic experiments to answer a number of key questions in applied machine learning to control the stiffness of selected parts of the body, to move in a constrained space, and to exert desired forces on soft objects with uncertain impedance parameters.
Probabilistic models such as hidden Markov models (HMM) and Gaussian mixture regression (GMR) will be explored to learn control policies that take into account variability and correlation information collected by consecutive trials. The learning problem will be explored 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).