Ph.D. in Information Technology: Theses Defenses

February 11th, 2019

Room Seminari – 10.00 am

Davide NICOLIS – XXXI Cycle

"A General Framework for Shared Control in Robot Teleoperation with Force and Visual Feedback"

Advisor: Prof. **Paolo Rocco**

Abstract:

Since the '50s, robot teleoperation has been employed in a variety of applications where a human user is required to operate from a distance a robotic device, often a robot manipulator. The use of telerobotics is often motivated by the inaccessibility of the environment where the task must be performed, caused by hostile conditions, such as on-orbit maintenance, and decommissioning of hazardous materials.

Currently, the topic of interaction between user and robotic devices has been receiving increasing attention from the research community and the industry. As teleoperation applications and platforms grow more complex, the employed control framework should be able to relieve the user of some of the burden caused by operating such devices, establishing a sort of shared control.

This work aims at proposing a comprehensive control framework for teleoperation systems. At a local lower control level, sliding mode control theory is employed to robustly shape master and slave manipulators impedances irrespectively of uncertainties. An outer hierarchical optimization layer considers control and motion constraints. To help and guide the operator, the specification of hard and soft virtual fixtures is included at this level, with virtual force feedback rendered through the dual solution of the optimization. A stability analysis of the overall control scheme in presence of variable communication delays is performed, providing tuning guidelines for the control parameters.

Furthermore, optical feedback by means of visual servoing is integrated and experimentally validated on a teleoperated dual-arm platform. The proposed controller helps the user in navigating cluttered environments and avoiding occlusions, reducing the operator workload required to complete a reaching task. Finally, machine learning techniques are employed to infer the user intention and predict his/her motion to actively assist in task execution and reduce fatigue.

Stefano SABATINI – XXXI Cycle

"An Autonomous Navigation Use Case for Last Mile Delivery in Urban Environment"

Advisor: Prof. **Sergio Savaresi**

Abstract:

Autonomous mobile robots are changing many industrial fields. Up to now their use has been limited to indoor confined applications (e.g. warehouse logistics) or outdoor applications in isolated areas (e.g. agriculture applications).

In the last couple of years, due to the boom of the e-commerce, a great interest has been raised around the possibility of using robots to deliver parcels navigating city's sidewalks.

Despite the enormous recent scientific and technological progress, urban environments still represent a challenge for robot autonomous navigation.

In the first place, it is clear the need of a robust sidewalk level localization solution that is able to cope with GPS inaccuracies typical of urban environments.

Furthermore, to navigate urban sidewalks, robots need to be extremely maneuverable and able to handle even the worst sidewalk surface conditions without getting stuck.

This research aims to address these challenges by developing and experimentally validating a complete autonomous navigation solution capable of navigating urban sidewalks.

An autonomous mobile robot named YAPE (Your Autonomous Pony Express) is designed from scratch based on a two wheeled self-balancing configuration.

This design, although more difficult to control compared to other robots, guarantees great maneuverability and the flexibility to handle sidewalk irregularities.

A method to map larg escale urban areas is also developed. Using a map-based localization system, sidewalk level localization is proved even in GPS degraded and denied environments.

The complete autonomous navigation system has been extensively tested in real-world situations on Milan urban sidewalks.

PhD Committee:

Prof. **Gianni Ferretti,** DEIB
Prof. **Corrado Guarino Lo Bianco**, Universita' di Parma
Prof. **Cristian Secchi**, Universita' di Modena e Reggio Emilia