Human-Centered Robotics and Haptic Interactions

Oussama Khatib
Department of Computer Science
Stanford University
khatib@robotics.stanford.edu

Summary

A new field of robotics is emerging. Robots are today moving towards applications beyond the structured environment of a manufacturing plant. They are making their way into the everyday world that people inhabit – hospitals, offices, homes, construction, and other cluttered and uncontrolled environments. While advancing into these new areas, current field and service robots are limited in their abilities to manipulate and interact with humans. The successful introduction of robotics into human environments will rely on the development of competent and practical systems that are dependable, safe, and easy to use. The value of their contribution to the work environment will have to be unquestionable and their task performance must be reliable.

Experiments with the Stanford Robotic Platforms: Ironing, cooperative manipulation, and door opening are examples of tasks demonstrated with the Stanford platforms.

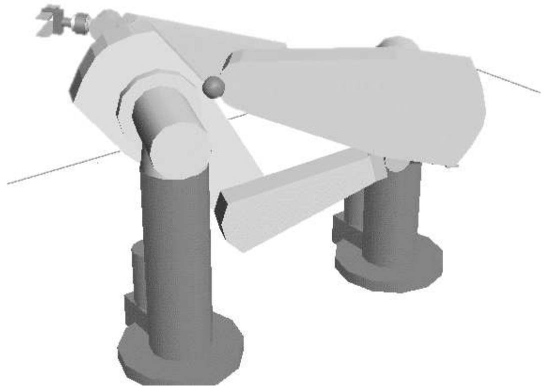
Typical operations are composed of various tasks, some of which are sufficiently structured to be autonomously performed by a robotic system, while many others require skills that are still

beyond current robot capabilities. Today, these tasks can only be executed by a human worker. The introduction of a robot to assist a human in such tasks will reduce fatigue, increase precision, and improve quality; whereas the human can bring experience, global knowledge, and understanding to the execution of task. During an assistance task, the robot must be capable of performing basic autonomous operations involving both navigation and manipulation. For more elaborate and delicate operations, the assistant, in its supporting role, must be able to interact and cooperate with the human when performing a guided task. The discussion focuses on models, strategies, and algorithms concerned with a number of autonomous capabilities that are essential for robot operations in human environments. These capabilities include: integrated mobility and manipulation, cooperative skills between multiple robots, interaction ability with humans, and efficient techniques for real-time modification of collision-free path. These capabilities have been experimentally demonstrated on the Stanford mobile robotic platforms.

In the second part of the presentation, we will discuss our ongoing effort in haptic display and real-time dynamic simulations of complex dynamic environments. Haptic interaction with an accurate dynamic simulation provide unique insights into the real-world behaviors of physical systems. The potential applications of this emerging technology include cooperative design, virtual prototyping in manufacturing, surgery, robotics, and education among many others. Haptics is one area where the computational requirement associated with the resolution in real-time of the dynamics and contact forces of the virtual environment is particularly challenging. This key issue is addressed in a new framework for the dynamic simulation and haptic exploration of complex environments. These developments have resulted in a number of new efficient algorithms for dynamic modeling and control and for the resolution of multi-contact and multi-impact between multi-body system. The effectiveness of this framework is demonstrated on various models of haptic interactions with complex environments.

Haptic interaction with virtual environments, real-time simulations of multi-body dynamics with multi contact and impact, and haptically augmented teleoperation of physical robots.

The new capabilities in robotics, haptics, and simulation are brought together in the development of a haptically augmented teleoperation system. The user interaction with a virtual environment is extended to the human guidance and teleoperation of a physical robot. The robot autonomous capabilities for task and posture coordination, compliant motion behaviors, and collision avoidance are combined with teleoperation capabilities that uses a haptic interface. Models and sensory feedback of the robot and its surrounding are augmented with teleoperation tools allowing the integration of task behaviors and the enforcement of various constraints. These constraints are designed to assist the human-user in performing delicate and precise operations, while maintaining safety and achieving increased performance.



A frame of an animation showing direct haptic interaction between the user and a simulated two PUMA arms in contact.

References

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