WTEC ROBOTICS WORKSHOP

RESEARCH AREA SUMMARY

Distributed Robotic Systems: Network robotics, Multi-Robot systems, Sensor Networks, and Environmental Applications

By

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While all fields of robotics have progressed based on rapid advances in computing and information systems, the field of distributed and cooperative robotics has been catalyzed in particular by new network and communications technologies. In the robotics context, the linkage of information systems by wired, wireless, or optical channels and protocols facilitates interactions that quickly scale from two robots shaking hands to a 'swarm' of microrobots demonstrating cooperative behaviors. The development of multiple robot and sensor communications links and the control of those distributed systems in laboratory and applications domains is the subject of these four sessions.

Network robotics has grown around the use of network communications channels, including the internet, as a means to remotely control robots, by humans, as well as support interobot interactions. Major challenges include the understanding of non-deterministic time delays in communications and the formulation of control and architectural principles that will enable robust performance. Key examples of network robotics include the remote teleoperation of space exploration robots and the shared internet access to robotic experiments.

The area of *multi-robot systems* has focused on the understanding of physical interactions and constraints among robots, and between robots and the physical environment. Such physical interactions may be direct, as in the shared manipulation of a single object, or indirect, as in the cooperative navigation of autonomous vehicles. Interactions associated with the physical reconfiguration of robotic systems are also of great interest. The theoretical formulation of underlying principles has been critical for this field, and forms the basis for systematic approaches to practical applications. Multi-robot systems research in the United States has been of particular interest for military and defense applications where multiple autonomous vehicles in land, sea, and air may provide important capabilities for future combat and defense systems.

The deployment of multiple robots in complex environments creates demands for *distributed sensor networks* in order to provide information and guide actions and decisions. The field of distributed sensor networks has been driven by the capability to fabricate microsystems with high functionality, low power, and wireless communications capability. The deployment of large numbers of such expendable devices would provide extraordinary access to information, and also support the deployment of autonomous robotic systems in the field. The challenges of improved microsensor specificity, sensitivity, power consumption, and communications are very clear trends in the field. In addition, a set of systems themes emerge with the need for coordination, adaptive communications, adaptive sampling, and integration with multi-vehicle control architectures.

Research areas associated with distributed robotics have a number of key applications, and the sessions on military and defense robotics and *environmental robotics* are particularly relevant to this research. Environmental robotics considers the deployment of distributed sensors and supported mobile sensor nodes to observe, monitor, and assess the state of complex environmental processes. Such applications may involve many different types of distributed sensing in land, sea, and air, and the coordination of mobile sensors through adaptive redeployment and adaptive sampling of environmental phenomena. The field of environmental robotics is rapidly emerging as an application of distributed robotics and key examples include the monitoring of regional industrial and land-use impacts in rivers and estuaries, and the observation of coastal regions that are subject to security and defense concerns.