Fundamental Advances in Control of Wireless Sensor and Robotic Networks

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Abstract: Wireless Sensor and Robotic Networks (WSRN), a significant evolution of Wireless Sensor Network (WSN), is composed of a group of wireless sensors, robots, and sink/central controllers interacting over a wireless network to perform an assigned task. In WSRN, the wireless sensors are low-cost, low-power devices with limited sensing, computation, and wireless communication capabilities. On the other hand, the robots and the sink/controller nodes are assumed to be endowed with superior computation, transmission, and higher power capabilities. Depending on the task at hand, a WSRN can possibly give rise to two basic communication architectures among the various nodes as shown in Figure 1 and 2.

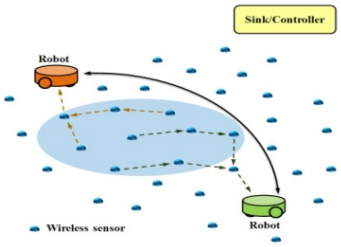

Figure 1: Automated architecture

For both architectures in WSRN, the robots can utilize the WSN to acquire information about an environment. Consequently, WSRN can not only monitor, but also act on that environment. However, as compared to WSN, there are several additional challenges in WSRN that arise primarily due to the fact that the WSRN have real-time performance constraints, and that the communication and coordination between sensor-and-robot, robot-and-robot, sink-and-robot occurs over an unreliable wireless network. The objective of this project is to guarantee real-time action by the robots on the sensed data, and to study coordination strategies between robotic systems over unreliable wireless networks.

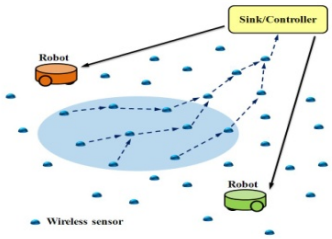

Figure 2: Semi-automated architecture

The following results have been obtained during the second year of the project:

1. A decentralized algorithm for estimating the algebraic connectivity of the communication graph is developed in [1]. The goal is to ensure, for arbitrary initial conditions, the maintenance of the communication connectivity between groups of agents.
2. Based on the scattering transformation, a control algorithm is proposed to solve the fundamental problem of controlling robotic systems with time-varying, input-output delays in the communication channels [2].
3. Robotic coordination is studied in [3] by the development of a control method for semi-autonomous teleoperation in the task space. The redundancy of the slave robot is utilized for additional tasks to enhance the overall performance of the system.

References:

1. L. Sabattini, N. Chopra, and S. Secchi, "On Decentralized Connectivity Maintenance for Mobile Robotic Systems," in *IEEE Conference on Decision and Control and European Control Conference*, to appear, 2011.
2. Y.-C. Liu and N. Chopra, "A New Architecture for Set-Point Control of Robotic Manipulators with Time-Varying Input/Output Delays," in *ASME Dynamic Systems and Control Conference*, to appear, 2011.
3. Y.-C. Liu and N. Chopra, "Semi-Autonomous Teleoperation in Task Space with Redundant Slave Robot under Communication Delays," in *IEEE/RSJ International Conference on Intelligent Robots and Systems*, to appear, 2011.