Mechanical Engineering Doctoral Defense

Decentralized Control of Collective Transport by Multi-Robot Systems with Minimal Information

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Abstract

One potential application of multi-robot systems is collective transport, a task in which multiple mobile robots collaboratively transport a payload that is too large or heavy to be carried by a single robot. Numerous control schemes have been proposed for collective transport in environments where robots can localize themselves (e.g., using GPS) and communicate with one another, have information about the payload's geometric and dynamical properties, and follow predefined robot and/or payload trajectories. However, these approaches cannot be applied in uncertain environments where robots do not have reliable communication and GPS and lack information about the payload. These conditions characterize a variety of applications, including construction, mining, assembly in space and underwater, search-and-rescue, and disaster response. Toward this end, this thesis presents decentralized control strategies for collective transport by robots that regulate their actions using only their local sensor measurements and minimal prior information. These strategies can be implemented on robots that have limited or absent localization capabilities, do not explicitly exchange information, and are not assigned predefined trajectories. The controllers are developed for collective transport over planar surfaces, but can be extended to three-dimensional environments. This thesis addresses the above problem for two control objectives. First, decentralized controllers are proposed for velocity control of collective transport, in which the robots must transport a payload at a constant velocity through an unbounded domain that may contain strictly convex obstacles. The robots are provided only with the target transport velocity, and they do not have global localization or prior information about any obstacles in the environment. Second, decentralized controllers are proposed for position control of collective transport, in which the robots must transport a payload to a target position through a bounded or unbounded domain that may contain convex obstacles. The robots are subject to the same constraints as in the velocity control scenario, except that they are assumed to have global localization. Theoretical guarantees for successful execution of the task are derived using techniques from nonlinear control theory, and it is shown through simulations and physical robot experiments that the transport objectives are achieved with the proposed controllers.

October 29, 2020; 10 AM;

Zoom Link: https://asu.zoom.us/j/94092160303