Rigidity Theory for Multi-Robot Coordination: Architectural Needs and Implementation Challenges

Abstract

The coordination and control of multi-robot systems represents an enabling technology for a wide-range of applications. Multi-robot systems benefit from an increased robustness against system failures due to their ability to adapt to dynamic and uncertain environments, and also provide numerous economic benefits by considering the price of small and cost-effective autonomous systems as opposed to their more expensive monolithic counterparts. Despite their clear benefit, integration of such systems into real-world settings is still limited due to the infancy of both a theoretical and implementation understanding of how these systems operate. This has motivated a growing and rich research area across many academic and industrial communities.

An important requirement for the successful implementation of these systems, therefore, is the identification of key *architectural* features these systems must possess. Such architectural requirements should be independent of any particular application. This can be likened to an "inner-loop" stabilizing controller for autonomous vehicles that enable higher-level commands, such as navigation or tracking. In this talk, we propose that the notion of *rigidity* represents one such necessary architectural feature for multi-agent systems. Rigidity theory has already proven important for applications related to formation keeping and localization, and provides a powerful framework for multi-robot systems. We will demonstrate how rigidity theory is useful in multi-robot systems with a variety of sensing capabilities, including relative-position sensing, range-only sensing, and bearing-only sensing. Thus, a necessary feature of these systems should include the ability to *maintain* rigidity throughout the duration of a given task. At the same time, we will also highlight some of the current implementation challenges related to this framework with an emphasis on specific problems that must be addressed for the future integration of these systems.