Distributed Formation Control of Heterogeneous Robots with Limited Information

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Abstract. In many multi-robot tasks, it is advantageous for robots to assemble into formations. In many of these applications, it is useful for the robots to have differing capabilities (i.e., be heterogeneous) in terms of perception and locomotion abilities. In real world settings, groups of robots may also have only imperfect or partially-known information about one another as well. Together, heterogeneity and imperfect knowledge provide significant challenges to creating and maintaining formations. This paper describes a method for formation control that allows heterogeneous robots with limited information (no known population size, shared coordinates, or predefined relationships) to dynamically assemble into formation, merge smaller formations together, and correct errors that may arise in the formation. Using a simulation, we have shown our approach to be scalable and robust against robot failure.

1 Introduction

Formations are desirable in collections of robots for many reasons, including maximizing area coverage, sensor coverage, and minimizing contact while moving quickly as a group. Heterogeneity in robots is similarly advantageous in many settings: parsimony in control, budgetary considerations, and specialization of tasks all make simpler robots with divergent capabilities desirable. Knowledge may be inconsistent between robots, making for more diversity, and commonly-assumed global knowledge may not be available. For example, in a rescue scenario, robots may be lost due to failure, and agencies may arrive with new equipment over time, preventing total population from being known with certainty. Communication may be noisy or temporarily disrupted, leading to inconsistency in information across members. All of these factors conspire to present a difficult challenge for the creation of formations and their maintenance over time.

In this paper, we present a distributed approach to formation control in multi-robot teams that deals with such challenging scenarios: robots may be heterogeneous in terms of movement abilities, sensing, and other equipment; knowledge of others, including identity and the overall size of the team, is assumed to be imperfect; and communication is assumed to be unreliable. Our