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On Distributed Cooperative Mobile Robotics: Decomposition of Basic Problems and Study of a Self-stabilizing Circle Formation Algorithm

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Abstract

Enabling mobile robots to work in cooperating teams holds great promises as an efficient and reliable way to solving tasks autonomously. However, addressing the coordination and control of autonomous mobile robots within a team remains a difficult task. Many people have addressed this issue by studying how a complex global behavior can emerge from the interactions of many robots exhibiting a simple local behavior. This approach, called behavior-based, can provide us with an interesting insight on these issues, but it also gives the wrong impression that they are solved. This is however very far from reality, since these heuristics can provide no assurance that a given problem will actually be solved, let alone any proof of correctness.

In contrast, we look at the problem from a computational standpoint, in the sense that we try to determine the local behavior of robots, given a desired global behavior. In particular, our work focuses on basic recurring problems of cooperation.

The main contributions of this dissertation are as follows. First, we outline a specification framework to define basic problems for cooperative autonomous mobile robots. The framework consists of four generic properties that can be combined to define various different problems, including many surveyed in the literature. We see this as a necessary step toward a better understanding of the problems and their relationships. Second, we take a closer look at a specific coordination problem whereby robots must coordinate themselves to form a circle. More specifically, we study the convergence of a self-stabilizing circle formation algorithm using computer simulation. This leads us to propose a simpler algorithm, also self-stabilizing, that has a faster convergence.