Gibbs Sampler-based Coordination of Autonomous Swarms

Probabilistic Graphical Models

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1 Introduction

The proposed work [1] deals with the self-organization of a large number of robotic swarms conducting a wide-area search. Given an initial configuration of robots, one wishes to find a distributed maneuver strategy under which the robots move to a new desired configuration. One such application is in mobile sensor networks deployed by unmanned aero vehicles, where the initial locations of sensors are random and they need to move autonomously into some configuration suitable for the mission. Another example is mission switching, where the nodes need to reconfigure for performing a new task. The large number of robots and the limited power for communication and signal processing as well as bandwidth limitations, prohibit centralized coordination in such task and necessitate a distributed, scalable approach.

Inspired by the emergent behaviors demonstrated by swarms of bacteria, insects, and animals, control methods that yield desired collective behaviors based on simple local interactions have received great interest in academia. Artificial potential functions have often been involved in these methods, where the motion of nodes is determined by the gradient flow. An essential problem with such approaches, however, is that the system dynamics may get trapped at local minima of the potential function.

2 Proposal

The work proposes a systematic approach to coordinate an autonomous swarm based on the theory of Markov Random Fields (MRFs) and Gibbs sampling. The approach aims to achieve global objectives (without being trapped at local minima) using primarily local interactions together with limited global interactions and obstacle avoidance. Figure 1 illustrates the scenario. A discrete-time path planning setting is considered, where robots are allowed to move on a discretized grid in a 2D space. A swarm is modeled as an MRFs on a graph, where the robots and their communication/sensing links constitute the vertices and the edges of the graph, respectively. As in the artificial potential approach, global objectives and constraints are reflected in potential functions—in this case, Gibbs potentials. The movement of vehicles is decided using simulated annealing based on the Gibbs sampler.

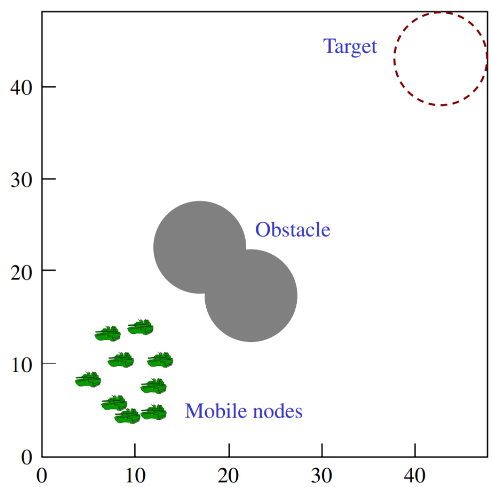

Figure 1: An example mission scenario with a circular target and a nonconvex obstacle (formed by two overlapping circular obstacles). Since the mission space is a discretized grid, a cell is taken to be within a disk if its center is so.

References

[1] Wei Xi, Xiaobo Tan, and John S Baras. Gibbs sampler-based coordination of autonomous swarms. *Automatica*, 42(7):1107–1119, 2006.