Switching of agent formations with collision avoidance and allowing variable agent velocities.

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We address the problem of dynamically switching the topology of a formation of a number of undistinguishable agents.

The need to switch formation topology arises in situations when mission requirements change or there are obstacles or boundaries along the formation path that are inadequate for the current topology. Here we propose a strategy to determine which agent should go to each of the new target positions, avoiding collisions among agents and assuming no agent communication. In addition, each agent can also chose its travelling speed from among a set of pre-defined velocities, which is a main distinguishing feature from previous work. Among all possible solutions we seek one that minimizes the total formation switching time, i.e. that minimizes the maximum time required by all agents to reach their positions in the new formation topology.

We describe an algorithm based on dynamic recursion to solve this problem and provide some examples.

A multi-agent system is any system in which two or more autonomous units interact to achieve a certain goal, such as formation switching. Formation control is an important area of multi-agent research not only because it is of theoretical importance, but also because it fulfills many practical needs. For example, suppose a convoy of vehicles is traversing unfamiliar territory. It may be desired that the vehicles change to a different formation for security purposes. Also, obstacles may be present along the path of travel leading to formation switching. Other similar examples exist, such as a team of autonomous robots moving through a building looking for intruders or certain hazards, once found another formation may be more appropriate to proceed. These examples demonstrate the practical importance of the conducted research.

If there are obstacles or boundaries along the formation path, the formation can be changed to another formation in order to avoid these obstacles. Here we propose a strategy to determine which agent should go to each of the new target positions with agent collision avoidance, assuming no agent communication. In addition, each agent can also chose its travelling speed from among a set of pre-defined velocities. Among all possible solutions we seek one that minimizes the total formation switching time, i.e. that minimizes the maximum time required by all agents to reach their positions in the

In the classical Assignment Problem as applied to multi-agent systems, there are m targets and n= m agents. Each target must be assigned one agent. A sense of optimality is obtained by associating a cost function (i.e. time) with the mapping of each agent to each target. It has been shown that a suboptimal solution can be obtained if the target assignment is obtained centrally, and then the agents are deployed and may travel decentrally to their respective targets. This solution applies even if rotation and translation of the targets is allowed and is particularly useful for formation assignment [11].

Zavlanos and Pappas demonstrate a decentralized solution that optimally assigns the agents to the targets and drives the agents to the target locations [4]. This solution allows the agents to be assigned dynamically and does not require a centralized, predetermined assignment. The authors present both a solution in which inter-agent communication is assumed [12] and a solution in which only inter-agent sensing is assumed [13].

Mesbahi and Egerstedt offer some algebraic methods for analyzing such systems. It is typical to associate a Laplacian matrix with a multi-agent network topology which captures information about the neighbors of each node. Mesbahi and Egerstedt demonstrate how to partition the Laplacian matrix such that the follower agents can be separated from the target agents, offering an algebraic framework for analyzing equilibrium positions in certain scenarios [14].

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