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Solving the Team Coordination on Graphs With Risky Edges problem for nonzero self-loop weights

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Abstract

Multiagent system control is a well researched area of recent years, since the co-operation of multiple agents opens up the possibility to tackle more complicated problems, and create finer scaling systems. Team Coordination on Graphs with Risky Edges [4] have been recently proposed, and provides a framework to model such systems. In this problem multiple agents traverse through a graph. Apart from the ordinary nodes and edges, the graph also contains support nodes, where an agent can choose to support another agent, that is moving through a so called risky edge, associated with the support node. Some solutions have already been proposed [6][5][2], however all of them assume zero cost of waiting, which is restricting in many real world problems. In this paper we generalize the problem, allowing non-zero cost of waiting, make a solution proposal and present our comprehensive simulation results.

1. Introduction

The Team Coordination on Graphs with Risky Edges (TCGRE) problem provides a framework to model multiagent scenarios, where the action of an agent can reduce the cost of the action of another agent. The agents operate on a weighted graph, representing points of physical or state space, and each agent's task is to traverse from their start nodes to their respective goal nodes, inducing the lowest possible cost. Some nodes of the graph, called *support nodes* are associated with certain edges, called *risky edges*. If an agent in one of the support nodes chooses, instead of moving, to support one of the associated risky edges of their current node, the other agent, that is traveling trough that edge in the same time step can do so for a reduced cost.

An example graph is given in Figure 1. There are two agents, traveling respectively from S1 to G1 and S2 to G2. Support nodes are C1, C2 and C3, the risky edges are shown in red and the association between them as green dashed arrows. The cooperation enables the agents to diverge from their individual shortest paths (marked as orange and yellow), to achieve lower cost through cooperation (blue and green).

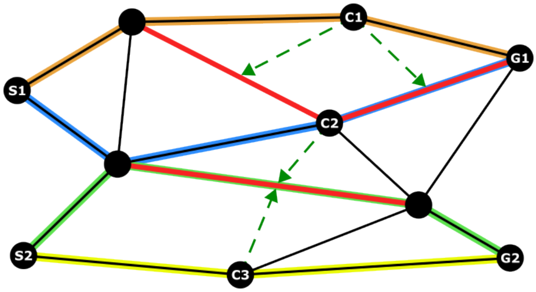

Figure 1. Example of a graph, containing support nodes (C1, C2, C3) and risky edges (red). While two agents are traveling from S1 and S2 to G1 and G2, they might stray from their individual shortest paths (orange and yellow), to cooperate and achieve lower total cost (blue and green).

Previously proposed solutions include integer programming [6], constrained exhaustive search [3] and reinforcement learning based approaches [5]. All of these solutions take advantage of that self-loops in the graph are present with $c_{i,i} = 0$ weights. In our opinion this assumption heavily restricts the applicability of the framework, thus we aimed to solve the problem while this constraint is eliminated, allowing any $c_{i,i} \in \mathbb{R}^+$.

2. Our contribution

During our recent work, we were able to develop an Ant Colony Optimization (ACO) [1] based approach [2]. Since the original TCGRE problem does not account for any collisions and waiting has essentially zero cost, the problem reduces to associating agent pairs with *support node-risky edge* pairs and organizing the order of execution.

This can be solved by the ACO through associating pheromones with the desirability of selecting each possible *supporter-receiver-support node-risky edge* pairings after any other. We were able to extend this approach by enforcing a strict synchronization of agent actions. This way the possible waiting between cooperations can be accounted for during the optimization process, enabling us to solve a generalized version of the TCGRE problem.

References

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