A Survey of ASP and SAT Encodings for Multi-Agent Pathfinding: Working Abstract

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Multi-Agent Pathfinding (MAPF; [11]) is the essential problem of finding paths for multiple agents on a shared graph while avoiding collisions. All agents have their own start and goal location. At each time step, agents may traverse a graph edge or wait at their current vertex. However, no two agents may simultaneously occupy the same node or cross the same edge in different directions; these conditions are known as vertex and edge constraints, respectively.

One straight-forward way to solve this problem is via search techniques, such as Conflict-Based-Search[4]. Another increasingly popular way, and the scope of this work, are declarative problem solving approaches using Answer Set Programming (ASP; [6, 10]) or Propositional Satisfiability (SAT; [3]). In sequel, we summarize our ongoing work on examining various declarative MAPF encodings from the literature and present some preliminary empirical results.

In total, we consider seven encodings, three from SAT[12, 1, 2] and four from ASP[5, 8, 9, 7]. Some require a grid-shaped graph as their movement actions are defined for the four cardinal directions, whereas others specify the explicit edge to be crossed. Common to all encodings is a fluent atom to represent the position of every robot for every time step.

The ASP encoding in [7] (ASPRILO) formalizes MAPF as a planning problem for movements on a grid. Further, wait actions are implied by inertia, and vertex and edge constraints are based on agent positions and move actions, respectively. Although similar in design, the ASP encoding in [8] (ASPMAPF) encodes both vertex and edge constraints purely relying on movement actions. In stark contrast, the SAT encoding [1] (SHIFT) introduces a new way of thinking about movement actions: instead of the agents moving from one vertex to another, the vertices move the agents. Consequently, instead of movement actions for agents, it uses shift actions for vertices. Eventually, the ASP encoding[1] (ASPMAPF-SHIFT) combines the ASPMAPF encoding with the concept of the SHIFT encoding. Some notable features from the other encodings are: in [2], the usage of aggregates for edge constraints; in [5], the choice rules for the next position of agents depending on the previous position; and in [12], supporting follow conflicts but not edge conflicts.

In a preliminary empirical study, we ran all encodings [1] against a smaller, self-generated set of experiments inspired by [11], consisting of room, maze, and

[1] For better comparability, the SAT encodings were translated to ASP, and all encodings were modified to also support non-grid graphs. We left out the SAT encoding [12] due its lack of recognizing edge conflicts.

random type instances with various graph sizes and number of agents. The ASPMAPF-SHIFT encoding performed best overall, reflecting the strength of the revised movement action. However, the ASPRILO encoding is close behind. Interestingly, the translated ASP version of the SHIFT encoding has severe grounding issues; however, it has one of the best performances when considering only solving.

In summary, our ongoing investigation of different declarative MAPF encodings is yielding some initial conceptual and empirical results that show promise for improving performance. At this stage, however, it seems unlikely that there is a single encoding that is best in every scenario. For the future, we will further deepen our analysis to identify key concepts, properties and differences of the various approaches.

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