Disjoint Splitting for Multi-Agent Path Finding with Conflict-Based Search
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Abstract
Multi-Agent Path Finding (MAPF) is the planning problem of finding collision-free paths for a team of agents. We focus on Conflict-Based Search (CBS), a two-level tree-search state-of-the-art MAPF algorithm. The standard splitting strategy used by CBS is not disjoint, i.e., when it splits a problem into two subproblems, some solutions are shared by both subproblems, which can create duplication of search effort. In this paper, we demonstrate how to improve CBS with disjoint splitting and how to modify the low-level search of CBS to take maximal advantage of it. Experiments show that disjoint splitting increases the success rates and speeds of CBS and its variants by up to 2 orders of magnitude.

Background
Multi-Agent Path Finding (MAPF)
MAPF is the problem of finding a set of paths for a team of agents on a given graph. Each agent is required to move from a start vertex to a goal vertex, while avoiding collisions with others.

Conflict-Based Search (CBS) [2]
1. Find a path for every agent independently.
2. Check for collisions among paths.
3. If there is a collision where both agent $i$ and agent $j$ are at vertex $v$ at time $t$:  
   - Option 1: prohibit $i$ from being at $v$ at time $t$ by adding a negative constraint $(i, v, t)$.
   - Option 2: prohibit $j$ from being at $v$ at time $t$ by adding a negative constraint $(j, v, t)$.
4. Repeat until finding collision-free paths.

Experimental Results
Figure 1: Success rate (= % of solved instances within 5 minutes) of CBS with non-disjoint splitting and disjoint splitting.

Conclusion: Disjoint splitting is at least as good as non-disjoint splitting and significantly speeds up CBS in many cases.

Open Question: Which Agent to Split on?
Empirically, strategies 1-4 performed similar, while strategies 5 and 6 performed slightly better.

<table>
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<th>Strategy</th>
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<td>6.</td>
<td>249.6</td>
<td>103.6</td>
<td>117.4</td>
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