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Peer Review

Review of: "Enhancing Lifelong Multi-Agent Path Finding with Cache Mechanism"

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1. Basic Reporting

The manuscript introduces a novel framework, *Lifelong MAPF with Cache Mechanism (L-MAPF-CM)*, aimed at improving the efficiency of lifelong multi-agent pathfinding (L-MAPF) in warehouse operations. By incorporating cache grids and a task assigner (TA) with a locking mechanism, the study addresses critical challenges in dynamic task allocation and collision-free routing for multiple agents.

Strengths:

- The introduction effectively establishes the importance of L-MAPF in autonomous warehouse operations, clearly distinguishing it from static MAPF problems.
- The manuscript is logically structured, with clear explanations of the problem statement, related work, and methodology.
- Figures, such as the warehouse maps in *Figure 1* and state machine diagrams in *Figure 2*, enhance clarity and understanding of the proposed framework.

Suggested Improvements:

1. **Expand the Literature Review**:
    - Incorporate more recent studies on caching strategies and multi-agent coordination. Suggested references:
        - https://doi.org/10.1016/j.eswa.2023.122147
        - https://doi.org/10.54216/JAIM.080101
        - https://doi.org/10.54216/MOR.010201

2. **Clarify Captions**:
    - Provide more detailed captions for figures, such as *Figure 4* (Throughput and Cache Hit Rates), explaining the significance of observed trends.

2. Experimental Design

The experimental setup evaluates L-MAPF-CM under various task distributions (MK, Zhang, and Real Data) and warehouse configurations, comparing it against a baseline L-MAPF model without a cache. Metrics such as throughput and cache hit rates are used to assess performance.

Strengths:

- The use of diverse task distributions and cache replacement policies ensures a comprehensive evaluation of L-MAPF-CM.
- The framework's compatibility with existing MAPF algorithms, like LaCAM, demonstrates its adaptability.

Suggested Improvements:

1. **Reproducibility**:
    - Include pseudocode or a repository link for the L-MAPF-CM implementation to facilitate replication.
2. **Dataset Details**:
    - Provide additional information about the datasets and task distributions used, including their real-world relevance and generation process.

3. Validity of the Findings

The findings show that L-MAPF-CM achieves significant performance improvements over the baseline, with higher throughput and cache hit rates across most scenarios. The results are supported by statistical analyses and visual representations.

Strengths:

- The cache mechanism's impact on throughput and collision avoidance is well-documented, with results clearly presented in bar and line charts.
- The detailed discussion on congestion effects and cache replacement policies adds depth to the findings.

Suggested Improvements:

1. **Error Analysis**:
   - Discuss cases where L-MAPF-CM underperformed, such as scenarios with high agent density or limited cache grids.
2. **Scalability**:
   - Address the feasibility of deploying L-MAPF-CM in larger, more complex warehouse environments.

4. Additional Comments

The manuscript introduces a practical and innovative solution to a key challenge in automated warehouse operations. Its interdisciplinary approach, combining robotics, caching mechanisms, and task planning, is commendable.

General Comments:

- **Applications**: Explore potential applications beyond warehouse operations, such as disaster response or multi-robot search and rescue missions.
- **Future Work**: Suggest developing advanced task assignment strategies with predictive capabilities or hierarchical cache systems for enhanced scalability.

Conclusion

The manuscript presents a novel and well-executed approach to enhancing L-MAPF using cache mechanisms. Incorporating the suggested revisions, particularly in reproducibility and scalability discussions, will further strengthen its contribution to the field.

Declarations

Potential competing interests: No potential competing interests to declare.