Off-line task assignment and motion planning algorithm considering agent's dynamics

With the advancement of automation in logistics warehouses and the flexibility of manufacturing lines, the demand for Automated Guided Vehicles (AGV) has been increasing. When operating a system composed of multiple AGVs, two problems need to be addressed: 1) task assignment, which determines where each AGV receives and delivers target products, and 2) motion planning, which generates path from initial to target positions with avoiding the collisions with other AGVs while completing tasks as quickly as possible. In order to find the optimal solution for these two problems, it is important to consider the dynamic characteristics of AGVs, which represents the specific acceleration/deceleration pattern of AGVs as shown in Figure 1. However, the algorithm which can perform both task assignment and path planning considering the dynamics of AGVs has not been proposed in previous studies.

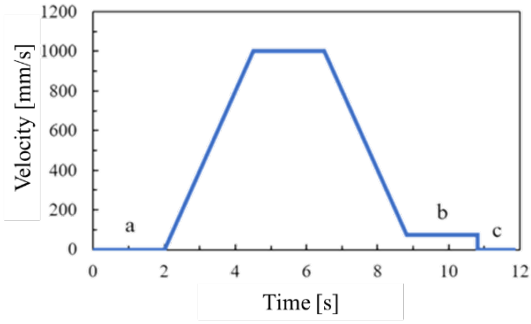

Figure 1. The dynamics (velocity curve) of the AGV used in this study. The AGV accelerates and decelerates following this curve.

Therefore, in this study, we developed an algorithm that performs task assignment and motion planning while considering the dynamic characteristics of AGVs and minimizing the time required to complete tasks including motion planning and movements of AGVs. Specifically, we used Conflict-Based Search with optimal Task Assignment (CBS-TA) [1], a representative solution algorithm for task allocation and motion planning problems, as a base and developed an algorithm that minimizes the time required to complete tasks by considering the dynamic characteristics of AGVs [2]. In our proposed algorithm, we introduced a heuristic function that reflects the dynamic characteristics of AGVs, assuming a speed curve as shown in Figure 1, and performed task allocation and motion planning using multiple search trees based on the CBS-TA framework. Furthermore, by continuously performing motion planning for both picking up and transporting the target products, we made it possible to achieve consistent optimization from task allocation to the completion of transportations.

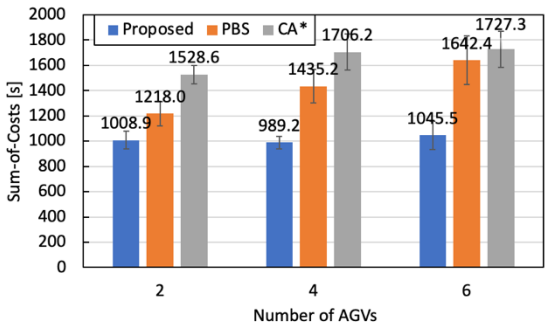

Figure 2. The result of the simulation experiment. The horizontal axis indicates the number of AGVs, and the vertical axis indicates the sum of the computation time of the motion plan and the total travel time of AGVs.

After implementing the proposed method on a computer, we conducted simulation experiments to verify its effectiveness. In the experiments, we randomly generated environments and solved the combinate problem of task allocation and motion planning for multiple AGVs while varying the number of AGVs, and compared the proposed method with the method of previous studies from the perspective of motion planning and the time required for task completion. As a result, as shown in Figure 2, it was demonstrated that the proposed method can perform both task allocation and motion planning for multiple AGVs within a shorter time compared to other methods. Based on the results of this study, in the future, we plan to further improve the proposed method while increasing the number of AGVs and setting up more complex environments.

Keywords: Automated Guided Vehicle, Path Planning, Task Assignment, Agent's Dynamics

References

[1] Hönig, W., Kiesel, S., Tinka, A., Durham, J.W., Ayanian, N.: Conflict-Based Search with Optimal Task Assignment. In Proceedings of the 17th International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS). *International Foundation for Autonomous Agents and Multiagent Systems*, 757765 (2018).

[2] Shimizu, T., Hattori, T., Taneda, K., Goto, A., Ota, J., (2022). Task Assignment and Path Planning Algorithm for Multiple AGVs Considering Agent's Dynamics. *Proceedings in the 40th annual conference of the Robotics Society of Japan (RSJ)*, RSJ2022AC2I2-08, pp. 1-4. (in Japanese)