Research on path planning of locally added path factor dijkstra algorithm for multiple AGV systems

Guorong Wu*, Xuan Sun*
1School of Mechanical Engineering, University of Jinan, Jinan, Shandong, 250022, China
*Corresponding author, e-mail: a 724855201@qq.com , b me_sunx@ujn.edu.cn.

Abstract. Aiming at the problem of relative encounter path conflict in multi-AGV systems under special working conditions, a path planning method is proposed to limit the running direction of AGV by adding path factor to Dijkstra algorithm. This method can realize simple traffic rule formulation. Effectively reduce the conflict of opposite encounter paths and achieve the purpose of orderly operation of multiple AGVs.

1. Introduction
The intelligent logistics system in industrial production workshops is an important part of intelligent manufacturing [1]. The AGV, which has the advantages of low cost, high efficiency, good flexibility and high reliability, is responsible for the main material handling tasks in intelligent logistics [2]. One of the key issues that multi-AGV has to deal with in intelligent logistics is the multi-AGV collision-free path planning problem [3]. If this problem is not handled properly, it will cause problems such as AGV blockage, deadlock and collision, which will seriously reduce the operating efficiency of multi-AGV systems [4]. In response to this problem, many scholars have proposed different solutions. For example, Guo Jinchao [5] et al. proposed a multi-AGV scheduling method based on traffic control; Dimitri Antakly [6] et al. proposed a delay by appropriate application. Time to avoid the method of emergency conflict; Toshiyuki Miyamoto [7] et al. proposed a local/random search method. These methods can better solve the path conflict problem of multiple AGVs in specific situations. However, not all factory conditions can use these methods to efficiently resolve conflicts. Different working conditions have their own unique characteristics, and it is necessary to take a unique method to solve the problem. A Dijkstra algorithm path planning method for locally adding path factors for this condition is proposed for the working conditions of the paper.

2. Working condition analysis
2.1. Workshop Overview
The multi-AGV operating conditions of the research project are as follows: there are 8 production lines in the workshop, the end of the production line is the product placement point, the work line is provided on both sides of the production line, and the stacking point of the stacking machine for loading and unloading goods is provided at the three-dimensional warehouse. When performing the task, the AGV needs to transport the products of the coded point to the warehouse for storage or to transport the materials from the warehouse to the station for use by the station. When the task
sequence has no tasks or the AGV needs to be charged, the AGV needs to return. Wait for the task or charge at the standby point. The working conditions of the workshop are shown in Figure 1.

![Figure 1. Schematic diagram of the working conditions of the AGV workshop](image)

According to the logistics needs of the workshop and the needs of the AGV itself, the scheduling tasks of multiple AGVs are divided into five categories: feeding task, warehousing task, charging task, returning standby point task and fault task.

The AGV used in this model is an omnidirectional AGV for laser navigation. In order to better establish the motion model of the multi-AGV system, it is assumed that the AGV operates at the same speed and the acceleration and deceleration time is extremely short.

2.2. Conflict Analysis
In the current multi-AGV system, there are four types of path conflicts: catch-up collision, node occupancy conflict, vertical encounter conflict and opposite encounter conflict [8]. The most complicated and difficult to solve is the conflict of opposite encounters. These conflicts involve the problem of mutual occupation. One of the vehicles needs to be avoided to make the vehicle pass smoothly. That is to say, one of the vehicles needs to travel around the road. The operation efficiency of the multi-AGV system is greatly reduced, so the occurrence of the phase conflict is minimized in the operation of the multi-AGV system.

3. Solutions to reduce conflicts in the opposite direction
3.1. Formulate traffic rules
For the plant model under study, traffic rules can be used to reduce the possibility of conflicts in the opposite encounter path. The five types of tasks mentioned above are divided into two categories: uplink tasks and downlink tasks. The uplink task mainly refers to the task of the AGV transporting the raw materials from the three-dimensional warehouse to the upper station; the downward task mainly refers to the task of the AGV to transport the products from the palletizer to the three-dimensional warehouse, in addition to the task. Charging tasks and going back to standby tasks.

According to the characteristics of the factory model, the traffic rules are set: the AGV is allowed to go up (the up, down, left and right here refers to the up, down, left, and right in Figure 2, the same below), that is, when the uplink task is performed, the left lane is taken as far as possible; when the AGV is walking down That is, when the downlink task is executed, the right lane is taken as far as possible; at the same time, when the task is assigned, the AGV that has just completed the feeding task is preferentially assigned to the inbound task, and the AGV that has just executed the inbound task is preferentially assigned to the feeding task, so that the whole can be made. The running path of the system forms a one-way ring, which greatly reduces the conflict of opposite encounters.
3.2. Adding a path factor to the Dijkstra algorithm locally

The system uses Dijkstra algorithm as the basic algorithm of path planning. When using the Dijkstra algorithm for path planning, a path factor is added to some of the paths in the model to achieve the purpose of formulating traffic rules.

As shown in Figure 3, when the system plans the path of the uplink task, add a path factor of 2 to the unidirectional path of P66-P67, P93-P97, and P66-P65. In this case, you can improve the execution of the uplink task to make the AGV take the left path. Possibility, for example: When the AGV performs the feeding task from P96 to the station P39, whether it is the shortest path from the left path or the right path, there is a 50% probability that it is going from the right side, it is likely to be executed from the right side. The AGV of the downlink task has a conflict of opposite encounters. After adding a path factor to the partial path in one direction, the AGV performing the uplink task can be restricted from traveling on the right path.

Figure 2. Schematic diagram of AGV running direction

Figure 3. Adding path factors to the upstream task
Figure 4. Adding path factors to the downlink task

When the system performs the downlink task, a path factor of 7 is added to the one-way side of P65% P66 and P92% P93, and a path factor of 2 is added to the one-way side of P72% P71. At this time, the AGV can be restricted from walking from the left path. For example, the AGV finishes the feeding task and reaches the P42 point. When returning to the P96 to continue the feeding task, the shortest path planned by the algorithm is from the left before the path factor is added. When the path is gone, the probability of collision with the AGV that is performing the feeding task is relatively high, and the addition of the path factor will restrict the AGV from descending from the left path, which meets the requirements of the traffic rules proposed above, and achieves the purpose of reducing the conflict of opposite encounters.

3.3. Case Analysis

Simulation experiments were carried out on the path direction of multiple AGV systems, and Open-TCS was used as the simulation platform. There are five tasks to be processed, three feeding tasks and two inbound tasks at the same time. The specific tasks are shown in Table 1.

| Serial number | Task type | Task start point | Task end point |
|---------------|-----------|------------------|----------------|
| 1             | Feeding task | P96              | P55            |
| 2             | Feeding task | P96              | P39            |
| 3             | Feeding task | P96              | P71            |
| 4             | Inbound task | P81              | P96            |
| 5             | Inbound task | P85              | P96            |

These five tasks are assigned to five AGVs for execution. The 1st to the 5th AGVs are executed for tasks 1 to 5. The AGV No. 3 starts from P42 and goes to P96 to perform task No. 3. The remaining AGVs are at the task starting point. Start performing the task.

The path planning before adding the path factor is shown in Figure 6. The path planning after adding the path factor is shown in Figure 7.
Figure 5. Schematic diagram of path planning before path factor addition

Figure 6. Schematic diagram of path planning after adding path factor

It can be seen from the above two figures that before the path factor limitation is added to the Dijkstra algorithm, the uplink task travels from the left side to the right side, for example, the task 1 goes to the P55 point V1AGV and executes the task in FIG. 2 Go to the V2AGV at point P39. At this time, the V1AGV planning path has a longer coincidence path with the route planned by V4 and V5AGV for performing the inbound task. If V1AGV meets the other two in this section, it will inevitably lead to an encounter conflict. At this time, V3AGV is going to P96 to perform task 3. The shortest path planned is to run from the left side, which will also have a high probability of conflict with the V2AGV that is performing the uplink task. Adding the Dijkstra algorithm After the path factor is limited, the AGV operates according to specific traffic rules. The path planning is shown in Figure 7, which can greatly improve the order of the multi-AGV system.

4. Conclusion
By adding the path factor to some of the paths during the path planning of Dijkstra algorithm, the running direction of the AGV is limited, and the system traffic rules are indirectly realized, so as to reduce the conflict of opposite encounters. At the same time, the model after adding the path factor does not lose the original bidirectionality of the lane. In some special cases, the AGV can also drive in the reverse direction. It is undeniable that the multi-AGV system with the added path factor will extend the certain running path for the driving path, but for the whole system, it can reduce the conflict of opposite encounters and improve the order of the system.

Acknowledgment
This work is supported by the national natural science foundation project (the project number is 51875250)

References
[1] Wang Y., Xie F., Liu Y., Zhu X. (2019) Research on Path Planning of Automatic Guided Vehicle Based on Improved Potential Field Ant Colony Algorithm. Manufacturing Automation, 41(07): 70-74.
[2] Cao X., Zhu M. (2019) Multi-agv Collision Avoidance Decision Optimization Method Based on Conflict Prediction. http://KNS.cnki.net/kcms/detail/11.5946.tp.20190812.0851.002.html.
[3] Guo J., Zhang F., Lan D., Cao H., Wang P. (2019) gwm-based multi-agv path conflict resolution algorithm. http://KNS.cnki.net/kcms/detail/41.1437.ts.20190823.1019.010.html.
[4] Chen Z., Lu S. (2017) Research on agv Path Based on Probability Model under Time Window Constraint. Logistics Engineering and Management, 39(10): 65-67+32.
[5] Guo J., Zhang F., Lan D., Cao H., Wang P. (2019) Design of Multi-agv Scheduling System Based on Traffic Control. Electrical Technology, 2019(16): 147-149.

[6] Dimitri A., Jean J.L., Rosa A. (2017) A Temporised Conflict-Free Routing Policy for AGVs. IFAC-PapersOnLine, 50: 11169-11174.

[7] Toshiyuki M., Kensuke I. (2016) Local and random searches for dispatch and conflict-free routing problem of capacitated AGV systems. Computers & Industrial Engineering, 91: 1-9.

[8] Liu J. (2018) Research and Implementation of Multi-agv Path Planning in Automated Warehouse Scheduling System. Chinese Academy of Sciences University, Shenyang.