Optimizing AGV Calculation MAP Path of Waste Smoke Recovery

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Abstract. With the emergence of Industry 4.0, Technological reform and technological model innovation will surely be launched in the industrial manufacturing industry. Based on the intelligent development direction explained by Industry 4.0 and the current status of the tobacco industry logistics, AGV for waste smoke recycling is proposed Example map route optimization topic. In the complex operation and maintenance environment of the tobacco industry, unmanned transportation technology is used to automatically recover the residual cigarettes in the wrapping workshop, replacing the traditional manual forklift recycling model. Focusing on the auxiliary production of intelligent production, with the automatic recycling of residual cigarettes as the core, we will further optimize and perfect the intelligent recovery or supply of production waste and other raw and auxiliary materials.

1. Introduction
Most domestic and foreign tobacco factories now use a recycling bin for each crimping machine to regularly collect residual cigarettes, and finally classify cut tobacco and weigh bad cigarettes uniformly, and record information. The current model often pays more attention to the timely recovery of residual cigarettes and the assessment level of the cigarette recycling rate of the machine. Not only does it require a lot of labor in the mass production mode, but it cannot be collected and applied to real-time bad smoke Data for the production management system to timely grasp the production status of the product and guide the operator to adjust the equipment status in a timely manner, achieve lean product terminal management, and create conditions for the realization of enterprise intelligent manufacturing.

Therefore, by using the “intelligent cigarette recycling cigarette recycling system” equipped with weighing, information wireless transmission and other technical means to realize the intelligent collection of residual cigarettes and the real-time transmission of residual cigarettes information, etc., the production management system can promptly grasp the operation status of the package receiving unit provides first-hand data support for cigarette quality monitoring.

Through the intelligent collection of residual cigarettes through the "Intelligent Cigarette Recycling Cigarette Recycling System", the traditional residual cigarette collection is changed to only recycle the residual cigarettes, while collecting the information of the residual cigarettes in the production process in a timely manner, investigation and disposal of bad cigarette The abnormal points generated and the status of the causes of bad smoke are analyzed to improve the overall production control ability.
2. Realization of Time Window Path Planning Strategy in AGV System

The Dijkstra algorithm is based on the use of a single AGV, and the multi-AGV path strategy implementation steps are as follows:

All tasks are sorted according to task priority and request time, with high priority first and time first. And zero the time window of each path. Iterate through the AGV collection, search for idle AGVs, assign transport tasks to AGVs in order, update the time window of each path, use Dijkstra’s algorithm to plan paths, and move the assigned tasks out of the task list. At the same time, the AGV performing the task is removed from the list of idle AGVs, and its status is marked as cargo. If the AGV completes the transportation task, the AGV is merged into the available AGV set, and its priority is cleared.

In order to complete all handling tasks within a fixed period, all tasks in the scheduling sequence should be repeated the steps of the multi-AGV path planning strategy.

![Figure 1. Example of path planning for multi-agv systems](image)

The calculation example map is shown in Figure 1. There are three transport tasks set by three idle AGVs. As shown in Table 1, the driving trajectory of each AGV is obtained through the Dijkstra algorithm. The time window of each path is initialized to obtain the ideal time window of each edge.

| Task NO. | Start | End  | Priority | AGV NO. | Route          |
|----------|-------|------|----------|---------|----------------|
| 1        | 0     | 14   | 1        | 1       | 0-1-2-3-4-9-14 |
| 2        | 12    | 1    | 2        | 2       | 12-7-2-1      |
| 3        | 9     | 2    | 3        | 3       | 9-8-7-2       |

\[
T(e_{0-1}) = \{(0,3),(0,0),(0,0)\} \quad T(e_{1-2}) = \{(3,10),(9,16),(0,0)\} \\
T(e_{2-3}) = \{(10,12),(0,0),(0,0)\} \quad T(e_{3-4}) = \{(12,15),(0,0),(0,0)\} \\
T(e_{4-9}) = \{(15,19),(0,0),(0,0)\} \quad T(e_{9-14}) = \{(19,24),(0,0),(0,0)\} \\
T(e_{7-12}) = \{(0,0),(0,5),(0,0)\} \quad T(e_{2-7}) = \{(0,0),(5,9),(5,9)\} \\
T(e_{8-9}) = \{(0,0),(0,0),(0,3)\} \quad T(e_{7-8}) = \{(0,0),(0,0),(3,5)\}
\]
Figure 2. Time window initialization without interference

Under the premise of no interference, the initial time window as shown in Figure 2 can be drawn that tasks 1 and 2 have overlapping time windows at $e_{1-2}$, and tasks 2 and 3 overlap at $e_{2-7}$ time windows. Relying on the time window path algorithm of the multi-AGV system path, tasks 1 and 2 are node conflicts, and the conflict can be resolved by waiting. According to the task priority level, 2 # AGV and other tasks 1 can execute the task after passing, so the time window is:

$$T(e_{1-2}) = \{(3, 10), (10, 17), (0, 0)\}$$

Task 3 is the same, and the final result is shown in Figure 3.

Figure 3. Time window initialization after algorithm execution

3. Design of Multi-AGV Path Planning Algorithm Based on Improved Time Window

If the AGV executes the transport task 2 to allocate the 12-7-2-1 track, it can avoid conflicts and complete the task quickly, as shown in Figure 3. Moreover, the towed AGV may occupy multiple paths while waiting at the intersection. The time window of the path planning algorithm has the following three steps:

1) Road congestion will affect the completion time of transportation tasks. Since the starting and ending points of raw and auxiliary materials are different at the production site of the Smart Factory, the congestion level of each road section will be different. The AGV performs the transportation task and waits for the congested section to most likely affect the timely feeding, so in this case, the fastest trajectory is not necessarily the shortest trajectory. The traditional Dijkstra algorithm considers the path congestion caused by multiple AGVs and defines the weight of the road segment at the same time.
(2) The path planning capacity will increase the cost of AGV path planning. In order to ensure that there is no chasing conflict in multiple AGV handling tasks, the time window allows each road section to pass only one AGV. Although the rear AGV runs in the same direction as the front car, the front car has a long body. The front car has to leave the road before the rear AGV can enter. Assuming that the trailer body is longer, the overall efficiency of the AGV system is greatly reduced under adverse circumstances.

![Figure 4. Path Planning Results of Basic Time Window Algorithms](image)

(3) The calculation of the two-stage method system is extremely large. As shown in Figure 4, planning the path first and then detecting the conflict is the traditional two-stage method of multi-AGV path planning. Because conflict detection is inconsistent with the planned path strategy, when the conflict cannot be resolved during the transportation process, the existing path planning needs to be abandoned. Recalculating all the paths puts extremely high requirements on the performance of the host computer, and fails to give full play to the AGV's handling efficiency.

4. Conclusion
This paper proposes the following three optimizations for the three major problems that exist in the basic time window of Dijkstra's algorithm: adding a congestion factor to the Dijkstra's algorithm of path weights. Apply the node time window to replace the original path time window. Combining the two-stage method, the Dijkstra algorithm simultaneously calculates the node time window and plans the next node.

5. References
[1] Riccardo Manzini. Mauro Gamberi. Kinematics analysis and simulation of series-parallel palletizing robot [J]. Int J Adv Manuf Technolmol, 2016, (28): 766-774.
[2] Pierpaolo Carieato, Antonio Grieco. Using Simulated Annealing to Design a Material-Handling System.IEEE Intelligent Systems, 2005, 20 (4):26-30.
[3] S. Endo, M.Konishi and T.Egawa. Motion Planning for MultiPle Mobile Robots by a Petri Net Approach.Proc [J]. Japan-U.S.A. Symposium on Flexible Automation, 2018:587-594.
[4] S.G. Lee, R.de. Souza and E.K. Ong. Dynamic analysis and structural optimization of a novel palletizing robot [J]. Computers in Industry, 2006, 30(3):241-253.
[5] I.Potre, T.Lerher, J.Kramberger, M.Sraml. Design and research of stacking robot kinematics [J]. Journal of Materials Processing Technology, 2014, 157-158, (20):236-244.
[6] Russell D Meller, Anan Mungwattana. Off-lineprogramming and remote control for a palletizing robot. IIE Transactions, 2016, 29(10):925-938.
[7] A. Noorul Haq, T. Karthikeyan M. Dinesh. Research on method of original point of new style industrial palletizing robot [J]. The International Journal of Advanced Manufacturing Technology, 2003, 22(5-6):374-379.

[8] M. B. M. de Koster, B. M. Balk. Benchmarking and Monitoring International Warehouse Operations in Europe [J]. Production and Operations Management, 2008, 17(2):175-183.

[9] Dukic Goran, Oluic Cedmir. Order-picking routing policies: Simple heuristics, advanced heuristics or optimal algorithm [J]. Strojinski Vestnik, 2014, 50(11):530-535.

[10] B. Kim, S. S. Heragu, R. J. Graves, et al. Clustering-based order-picking sequence algorithm for an automated warehouse [J]. International Journal of Production Research, 2013, 41(15):3445-3460.

[11] B. Kim, S. S. Heragu, Graves, R.J., et al. A Hybrid scheduling and control system architecture for warehouse management [J]. IEEE Transactions on Robotics & Automation, 2013, 19(6):991-1001.

[12] H. F. Lee, E. Chung. A set-based scheduling problem for square rack automated storage and retrieval systems [C]. IEEE International Conference on Service Operations and Logistics, and Informatics, 2016:393-398.

[13] Y Khojasteh-Ghamari, JD Son, J Korea. Order Picking Problem in a Multi-Aisle Automated Warehouse Served by a Single Storage/Retrieval Machine [J]. International Journal of Information and Management Sciences Chang C T, 2018, 19(4):651-665.

[14] F.T.S. Chan, V. Kumar. Path planning method for palletizing tasks using workspace cell decomposition [J]. International Journal of Production Research, 2009, 47(4):919-940.

[15] J. Y. Shiau, C. M. Lee. Research of Control Characteristic of Palletizing Robot Based on PMAC [J]. Computers & Industrial Engineering, 2015, 58(3):382-392.

[16] S. R. Nenad. Study of dynamic simulation and control algorithm of palletizing robot [J]. IEEE Transactions on Automation Science and Engineering, 2015, 7(1):151-155.

[17] J. J. Thomson. Kinematics analysis for a 4-DOF palletizing robot manipulator [C]. IEEE International Conference on Robotics and Automation, 2011:1-4.

[18] KOTA L and JARMAI K. Mathematical modeling of multiple tour multiple traveling salesman problem using evolutionary programming [J]. Applied Mathematical Modelling, 2015, 39(12):3410-3433.

[19] JPVD Berg, WHM Zijm. The kinematic self-calibration method and simulation of one palletizing robot [J]. Int. J. Production Economics, 2015, 59:519-528.