Development of Path Planning Approach Based on Improved A-star Algorithm in AGV System

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Abstract. Automate guide vehicle (AGV) has been widely applied in industry. Therefore, it is important to design a highly efficient AGV. The path planning is known as one of the key factor for AGV operation. Although typical A-star algorithm with a heuristic mechanism can be used in the shortest path searching, it may suffer from broken lines and redundant nodes. In this paper, an improved A-star algorithm is presented. Based on the initial path planned by A-star algorithm, traversing all the nodes on an initial path and deleting unnecessary nodes and connections, the proposed model can remove the superfluous inflection points and redundant nodes effectively so that no obstacles exist during AGV moving. The performance results reveal that the proposed method can provide more efficient path planning with a shorter route and less turn times.

Keywords: Automate guide vehicle (AGV) · A-star algorithm
Floyd algorithm · Path planning

1 Introduction

In recent years, AGV has been widely in a warehouse or other areas. It is known that the transport efficiency is determined by an effective path plan [1–3]. For this reason, it is an indispensable task to find the efficient path for AGV. It is found that one of the biggest challenge is how to eliminate the excess inflection points in the path and effectively improve the efficiency of transport. An algorithm for solving optimal path planning problems was reported based on parameterization method and fuzzy aggregation [1]. A genetic algorithm was also used to find an effective path planning in a mobile robot [2]. Another path planning for AGV transport system was studied in a manufacturing environment recently [3]. In this study, it is more focused on AGV system operated in a warehouse environment. An improved A-star algorithm is proposed to present an effective path planning than traditional methods.

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2 Algorithm Principle

A-star algorithm is a heuristic search algorithm to find the node with the least cost by traversing the surrounding nodes, and the target point can be achieved from next node searching [4–6]. Evaluation function $F(n)$

$$F(n) = G(n) + H(n) \tag{1}$$

Where n is the node that is currently being expand. $G(n)$ is the distance from the start node to the current node n along the planned path. Heuristic function $H(n)$, $H(n)$ is the minimum cost estimate from the node n to the end node, and less than the actual cost.

Define the coordinates of the current node n and target node to be (x_1, y_1) and (x_2, y_2)

$$H(n) = sqrt\ [(x_1 - x_2)^2 + (y_1 - y_2)^2] \tag{2}$$

$$F(n) = G(n) + sqrt\ [(x_1 - x_2)^2 + (y_1 - y_2)^2] \tag{3}$$

2.1 A-star Algorithm Flow

The open table and the close table are applied to store the information of nodes, which include the nodes in the planed path and surrounding nodes, the open table store the information of minimum cost and the close able store the node in the planed path.

(1) Place the start node into the open table and calculate $F(n)$. **(2)** Place the node with the minimum $F(n)$ in the open table and the $F(n)$ into the close table, if the node is the start node, place the start node and the its $F(n)$ into the close table. **(3)** Determine whether the current node in the close table is end node, if the node is end node, the A-star algorithm is finished, and if not, go to the step 4. **(4)** Expand the surrounding nodes by unit step, calculate their $F(n)$ and place the nodes and $F(n)$ of the nodes into open table. **(5)** Sort the surrounding nodes in the open table according to $F(n)$ and return to the step 2 (Fig. 1).

2.2 The Principle of Improved A-star Algorithm

In this paper, the nodes planned by A-star algorithm were quadratic programmed by Floyd algorithm which is used to smooth the A-star algorithm [3]. The improved A-star algorithm consists of two parts: the first one is traversing all the nodes from an initial path, merging the path node on the same line, and the last part is deleting the nodes which prolong the length of initial path with no obstacle existing on the line connected nodes.

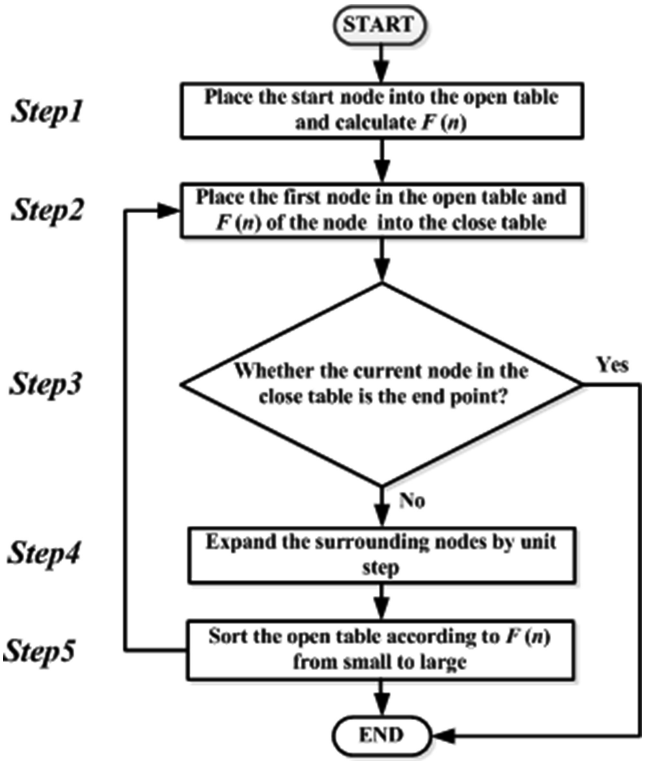
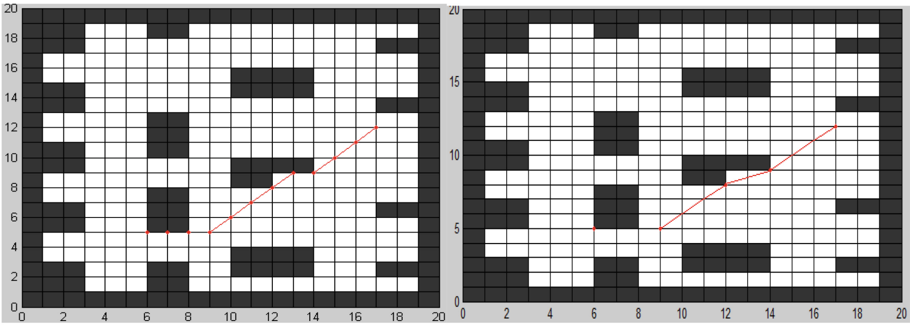


Fig. 1. A-star algorithm flow

3 Performance Results and Analysis

For this study, the warehouse map shown in Fig. 2 is simulated by MATLAB from an actual AGV warehouse environment, where the black grids represent the obstacles, and the red line is the path of AGV moving. The AGV paths planned by traditional A-star algorithm and improved A-star algorithm are shown in Fig. 2a, b, respectively. It is obvious that the proposed improved A-star algorithm indicates a better solution, i.e., shorter route. Also, the turn times from the A-star algorithm is 4, but the improved A-star algorithm requires only 3 times. The comparison of performance efficiency for AGV is shown in Table 1.



(a) (b)

Fig. 2. Comparison of the path of A-star algorithm and improved A-star algorithm. (a) A-star algorithm (b) improved A-star algorithm

Table 1. The comparison of performance efficiency for AGV.

Algorithm	The length of path	Turn times
A-star	11.98	4
Improved A-star	10.78	3

4 Conclusions

In a warehouse environment, it is important for AGV to choose an effective path so that the transport efficiency can be increased. The proposed improved A-star algorithm proves that it can eliminate the excess inflection points in the path and provide more effective path plan than traditional A-star algorithm in the transport system. Therefore, the proposed model is feasible to be applied to AGV path plan in industry.

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