Research on scheduling algorithm of multi-AGVS system

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***Abstract*—Due to the rapid development of global economy, the demand for Automated Guided Vehicles System(AGVS) scheduling is increasing in the production and transportation industry.As an automatic guide device that can transport a specified item to a specified location, Automated Guided Vehicles (AGV) greatly reduces the transportation efficiency and transportation cost.Among the basic AGVS scheduling, task management and path control are the two most widely studied and valued tasks.We construct a new integration model for scheduling problem and conflict-free routing problem of multiple AGVs.A new mathematical programming model is developed, and the ant colony algorithm (ACA) is applied to solve the model.The algorithm is optimized based on multi-objective programming, working similarity and pheromone matrix.A scheduling experiment is used to find the optimal path, and the performance of ACA is compared with that of precise algorithm.The results show that although the precise algorithm can accurately solve small scale problems, the improved ant colony algorithm is more suitable for medium and large scale problems than the precise algorithm, which shows the credibility of ACA to solve medium and large scale problems.Therefore, it can be concluded that the improved ant colony algorithm has the ability to provide task management and path planning for large-scale AGVS scheduling problems in an acceptable time range.**

Keywords: AGVS;Scheduling algorithm;Ant colony algorithm

I. Introduction

In the process of warehousing and logistics, loading, unloading, transportation and other processes take up most of the time of the whole logistics process. AGV is recognized as a good solution for material handling because of its higher efficiency and good flexibility, which reduces the material transportation cost in the total cost and improves the space utilization rate of logistics warehouse[2].In these indoor logistics systems, it may be necessary to use multiple AGVs to perform multiple transport tasks at the same time.Therefore, these AGVS are critical to planning an efficient AGV system (AGVS) that is conflict-free and collision-free.AGVS is the general name of a whole set of systems composed of automatic guided vehicle, upper control system, guidance system, communication system and charging (supply) system[1].However, the design and control of AGV system is not easy to operate, and the biggest challenge comes from the scheduling system for task management, vehicle monitoring and traffic management in the upper control system[1].Therefore, the establishment of an efficient multi-AGVS scheduling system can further improve the structure of logistics and transportation system, reduce logistics and transportation costs, improve system operation efficiency, and has important application value in intelligent warehousing and logistics.However, in the real warehouse, due to the dynamic changes of AGV storage location and environmental information, complex road conditions may lead to congestion and collision problems. Therefore, screening the optimal task set and path for AGV is the most fundamental task.

The production shop considered in this paper is arranged with the same embedded dedicated network guide rails which do not allow AGV to move in all directions, i.e. AGV can only move along the guide rails.In the early stages of conflict-free routing scheduling, basic information such as the number and location of machines, the process of the job to be processed, and the number of vehicles is first understood[4]. The ultimate goal is to find the correct processing sequence in which the workpiece is processed. Ensure conflict-free transportation routes and process all parts in a minimum time frame [5].

II. Improvement and simulation of ant colony algorithm

A Ant colony algorithm overview

Ant colony algorithm (ACA) is a famous meta-heuristic intelligent search algorithm first developed by Dorigo, Maniezzo and Colorni (1991) in the early 1990s[9], the best path can be found through distributed collaboration. See Figure 1,a swarm of ants is moving along A and E.Suppose A is the ant's nest and E is the food the ant finds.The ants are going to move along the AE line.But if a rock suddenly appears between A and E, the ant at B or D must decide whether to drive left or right.Since the ant in front didn't leave any pheromones behind, the ant could have moved in either direction.But when an ant passes by, it releases pheromones in its path, one of the ants' tools for communicating with each other.Pheromones disappear at a certain rate.The ant behind it decides whether to go left or right based on the pheromone concentration in the path.It is clear that pheromones will become increasingly concentrated on the short path, attracting more and more ants to move along the path.

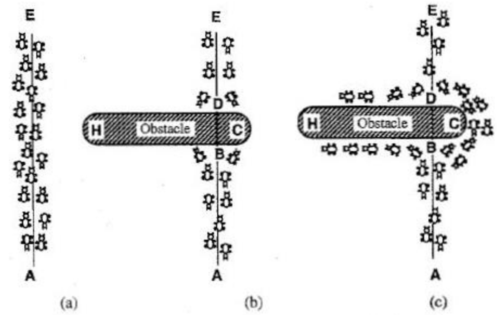

Figure 1 Schematic diagram of ant colony algorithm

B The advantages of ant colony algorithm

Ant colony algorithm as a multi - agent random search algorithm[12], has a strong optimization ability, is widely used in the workshop scheduling, vehicle routing and other problems.However, ant colony algorithm also has some unique disadvantages[8].(1)The operation time of the ant colony algorithm is relatively long.In the face of more iterations and ant numbers, the search speed of the algorithm will become slower.(2) The feedback mechanism of ant colony algorithm is a positive feedback mechanism. Although the algorithm has a good convergence speed, it is easy to fall into the local optimal solution and difficult to jump out[7].(3) Although ant colony algorithm is suitable for solving various problems, it has the problem of optimization ability.For example, when solving path planning problems, taboos set on each node will cause the program to appear "deadlock".[10].

C Algorithm improvement

In the research of ant colony algorithm at home and abroad, there are many improved algorithms, such as the improvement based on pheromone, based on the improvement of heuristic information, this paper mainly focuses on the adaptive ant colony algorithm for discrete domain optimization problems.

- *To improve the direction*

In the ant colony algorithm, the heuristic information is improved[3].The multi-AGVs scheduling problem studied in this article is as follows: In the shop environment of an operating system, one or more machines are required to handle many jobs.These jobs take different paths and require different machines to complete the process.Therefore, this paper makes the following assumptions: (1) All AGVs have unit working capacity and will not fail during continuous operation;(2) All AGVs are in standby state, all jobs are in the state of waiting to be processed, and no new jobs can be added after the processing sequence is determined;(3) The starting point and ending point are on the network;(4) AGV loading time is ignored;(5) In the next time unit, only one job is assigned to each AGV, and no machine can handle more than one job at a time;(6)AGV moves operations from the starting point of the warehouse to the first pick up and delivery point of the required machine via a network-boot path;(7)The vehicles carrying the job cannot transfer the job to other vehicles, they must wait for the machine to complete the job processing, and if necessary receive the job and transfer it to the subsequent machine.Otherwise, they move to the end of the warehouse;(8)AGVs should not collide with each other in the course of routing, i.e., to achieve conflict-free routing.

- *Algorithm to improve*

(1) Global update rules

In the general ant colony algorithm, a transfer update is performed after the ant colony finishes a path search. However, in the improved formula 1, the update is only applicable to the ants with the optimal path search, that is, only the pheromone content on the path of the global optimal solution is increased.

$$\begin{cases} \tau_{ij} = (1-\rho)\cdot\tau_{ij} + \rho\Delta\tau_{ij} \\ \Delta\tau_{ij} = \begin{cases} \frac{1}{L_{gb}}, & ij\ is\ the\ global\ optimum \\ & and\ L_{gb} is\ the\ shortest\ path \\ 0, & other \end{cases} \end{cases} \quad (1)$$

(2)Local update rules

At the same time, the improved algorithm also added a local update rule that adjusts the information amount on the path during each iteration update, as shown in formula 2. When ants move from node I and node J, pheromone on the path will decrease.

$$\tau_{ij}(0) = \tau_{max}$$
$$\tau_{ij}(t+n) = (1-\rho)g\tau_{ij}(t) + \Delta\tau_{ij}^{min} \quad (2)$$
$$\Delta\tau_{ij}^{min} = \frac{Q}{L},\ L = \min(L_k), k = 1,2,\dots,m$$

(3)State transition rules

The transfer probability of ants is also improved.$p_{ij}^{k}(t)$As shown in formula 3, the transition rule becomes the pseudo-random ratio rule, where it refers to the constant between 0 and 1, and Q is the random number during the period.q_0The next transfer node is determined by comparing the size of the two.That is, if the next node visited by the ant is the node with the maximum value in the equation, otherwise, the transfer probability is still used to judge the next node visited.$q \le q_0$

$$\begin{cases} argmax_{s\in J_k(i)}\{[\tau_{is}(t)]^{\alpha}\cdot[\eta_{is}(t)]^{\beta}\}, & q \le q_0 \\ p_{ij}^{k}(t) = \begin{cases} \frac{[\tau_{ij}(t)]^{\alpha}\cdot[\eta_{ij}(t)]^{\beta}}{\sum_{s\in J_k(i)}[\tau_{is}(t)]^{\alpha}\cdot[\eta_{is}(t)]^{\beta}}, & q > q_0 \\ 0, & other \end{cases} \end{cases} \quad (3)$$

The improved ant colony algorithm initializes the population and each parameter before the algorithm operation, and sets the iteration times.Then the ants were randomly distributed to each node and tabu table were set up.The transfer probability of an ant was randomly calculated according to the transfer probability formula in the improved algorithm, and the next node to be visited was selected. The path distance traveled by each ant in the batch path searching process was recorded, and the shortest path distance and average distance were calculated and recorded. The pheromone increment and pheromone quantity on each path were calculated after the search for the optimal path of this batch of ants was completed, the pheromone on the optimal path was updated, the number of iterations was increased by 1, and the tabu table was cleared.Finally, judge whether the set number of iterations is completed or whether the ant colony has stopped searching. If the algorithm is completed, the optimal path can be obtained.If not, let the colony of the last batch of ants disappear and conduct the path query of the next batch of ants.

D The simulation implementation

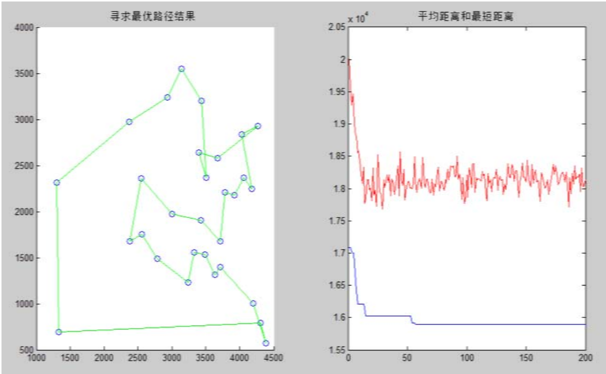

Figure 2 Improved result of ant colony algorithm(1)

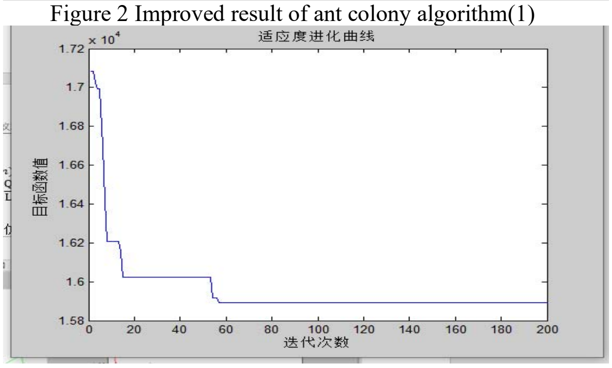

Figure 3 Improved result of ant colony algorithm(2)

As shown in Figure 2, the result of seeking optimal path on the left shows the optimal path result obtained by the improved ant colony algorithm on the map of 4000*4500, while the waveform chart of average distance and minimum distance on the right shows the changes of average distance and minimum distance in the whole algorithm as the number of iterations increases.

As shown in Figure 3, the fitness evolution curve shows that the objective function value of the ant colony algorithm after each iteration, that is, the length of the optimal path changes with the number of iterations, gradually tends to be stable, indicating the accuracy of the improved algorithm for optimal path search.

- *The results are analyzed*

According to the running time and quality of the algorithm, the initial ant number was set as 30, the number of iterations was set as 200, and the pheromone volatilization coefficient was set as 0.5.According to the results in Figure 2 and Figure 3, for large-scale problems, precise methods cannot find feasible solutions within acceptable time, while classical ant colony algorithm and improved ant colony algorithm can find feasible solutions.Acceptable time.Therefore, the improved algorithm provides acceptable solutions to a wider range of problems than the precise method.This shows that the improved algorithm has better optimization ability.The improved algorithm is superior to the original ant colony algorithm, thus reducing the possibility of falling into local optimum.

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