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Development of Automatic Terminal AGV Equipment Control System based on Internet of Things

Jiurong Fan

Yunnan Open University, Yunnan Kunming 650101, China

Abstract: With the rapid growth of international container trade, container terminals are playing an increasingly important role in the global shipping industry. In order to cope with the problems of large-scale ships and rising labor costs, ports are gradually turning to the construction of automatic or semi-automatic container terminals. The automatic guided vehicle(AGV) is the main horizontal transportation equipment between the shore and the storage yard in the automated wharf. Its operation efficiency is one of the key factors affecting the service quality of the automated wharf. Therefore, the design and development of the terminal automatic AGV control system based on the Internet of things technology in this paper can play a reference role in the actual scheduling of the container terminal to a certain extent.

Keywords: Internet of things; Container; Wharf; AGV equipment; Control system

Introduction

The horizontal transportation system of container terminal is a complex and dynamic system engineering. It is a network system composed of information flow, logistics and energy flow. In container logistics, horizontal transportation is often the main factor affecting the handling efficiency of container terminals. Therefore, in order to improve the working efficiency of the container terminal, it is necessary to carry out integrated and optimized scheduling for the horizontal transportation of the terminal, so as to reduce the turnover time and operation cost of containers. In the process of container loading, the optimal scheduling of horizontal transportation first determines the “appropriate” container, then schedules the “appropriate” loading and unloading and transportation equipment, and completes the container loading operation according to the optimized loading and unloading sequence. In this process, the operation sequence of horizontal transportation equipment is optimized to improve the operation and production efficiency of container terminal based on the principle of reducing the waiting time between horizontal transportation equipment.

1. Operation line scheduling mode

In the container terminal, AGV mainly serves the horizontal transportation of containers between the quay bridge and the storage yard, and between the storage yard and the storage yard. The “operation line” scheduling mode is usually adopted, that is, in the process of container loading or unloading, an AGV is fixed to serve a quay Bridge, or a quay bridge has several fixed AGVs to provide services. Until all tasks are completed, new tasks can be reassigned to serve other quay bridges. During the dispatching operation, the driving route of each AGV is relatively fixed. During the circulation between the shore bridge and the storage yard, as well as between the storage yard and the storage yard, the AGV has the phenomenon of empty driving, that is, it runs empty without loading containers. Figure 1 is the flow chart of “operation line” scheduling mode.

According to the schematic diagram in Figure 1, the main process of “operation line” scheduling is introduced in detail: when the ships are berthing, they are divided into inbound ships that are about to unload the imported container goods and outbound ships that are about to load the exported container goods. The central control room of the container terminal configures the quay bridge at the front of the terminal in a certain proportion according to the specific number of imported and exported containers, ship stowage, bay position of the storage yard and other factors The number of gantry cranes and AGVs loading containers in the container yard. After the task is assigned, the AGVs will serve a certain shore bridge and gantry crane until all rated tasks are completed. A fixed number of AGVs are dedicated to carrying containers from the berth of the import container to the import container area of the yard. Similarly, a fixed number of AGVs are dedicated to carrying export containers from the export container area of the yard to the export berth, The container is loaded onto the container export ship by the bridge crane. Under this scheduling mode, the transportation status of the AGV is divided into heavy load and empty driving. The container studied in this paper is a standard 20 foot container. The solid line in the figure represents the heavy load status of the AGV, and the dotted line represents the empty driving status of the AGV without loaded containers.

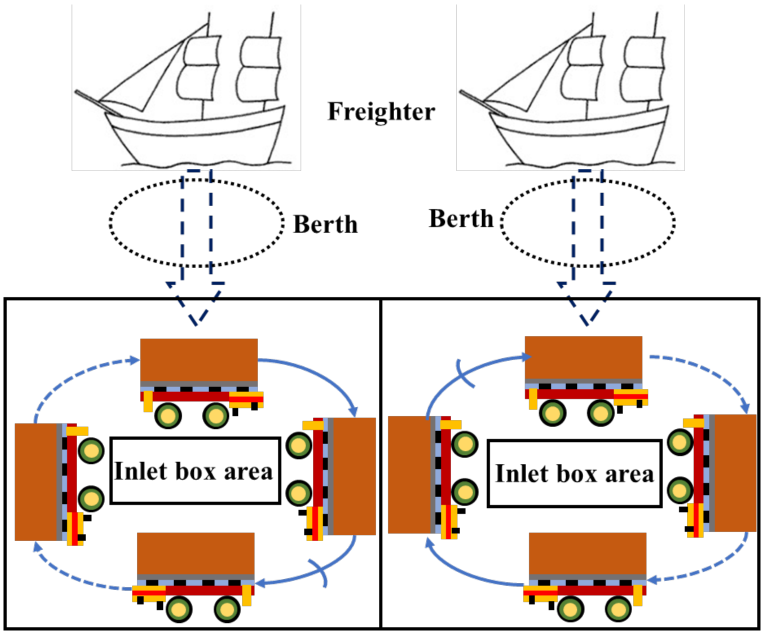

Fig1 The flow chart based on the "line" scheduling model

2. AGV real-time scheduling optimization algorithm

With the increase of the scale of the problem, it is difficult to obtain high-precision optimal solution in the effective time. The traditional AGV scheduling scheme can not make real-time policy adjustment for the change of dynamic environment. According to the characteristics of the problem studied, an AGV real-time scheduling optimization algorithm based on DBN network model is designed. The algorithm calculates the real-time preference value of the optional scheduling scheme through the preference function, completes the arrangement of AGV task containers and job sequences, and selects the appropriate exchange area and travel path for them; In order to minimize the job completion time, the preference policy is updated in real time based on the DBN model. The algorithm flow chart is shown in Figure 2, and the overall steps are as follows.

Step 1: input the list L of non operating containers and the initial scheduling policy π; Simulation step S, initial training set I (empty set), standard training set capacity C and other parameters. Allocate the initial operation scheme to all AGVs according to the initial scheduling strategy, and update the current time t;

Step 2: update the status of the exchange area and shore bridge / yard bridge according to the current time t. If t is the time when an AGV arrives at the exchange area to start loading and unloading, execute Step3; If t is the time when an AGV reaches the idle state, execute Step4.

Step 3: update the operation status of the exchange area, yard bridge / shore bridge and the number of AGVs on the driving path,

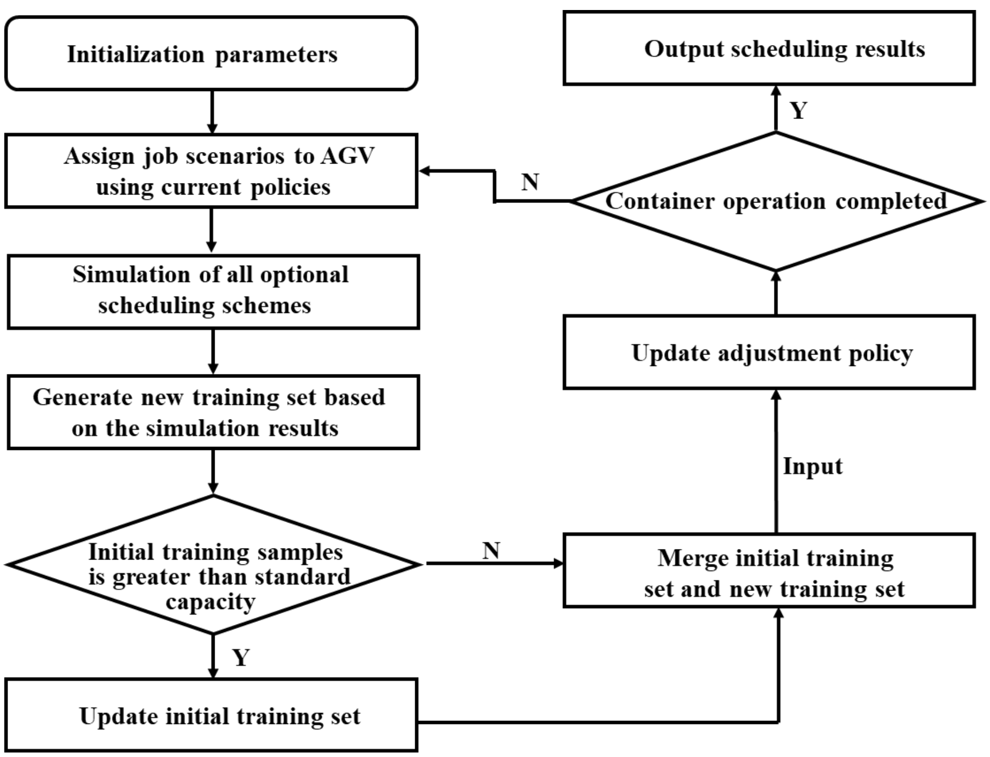

Fig 2 The algorithm flow

update the current time t, and execute step 2;

Step 4: update the currently available scheduling scheme set Q. According to the current scheduling strategy π, arrange the optimal scheduling scheme for the idle AGV, that is, select the appropriate container, initial job exchange area, travel path and target job exchange area;

Step 5: carry out simulation with step size of s for all selectable scheduling schemes. Assume that scheme x is arranged for the idle AGV, and continue to simulate the distribution of s containers to obtain the evaluation value V (x) of X;

Step 6: initialize the temporary training set P (empty set), compare the evaluation value V (x) and obtain the optimal simulation scheme x*, x*=$arg_{x\in Q}^{min}V(x)$. Generate a temporary training set P, $P\leftarrow P\cup(x^*,x,1)\cup(x,x^*,0),\forall x\in Q-\{x^*\}$;

Step 7: if the number of samples in the training set / is greater than the capacity C, C samples are randomly selected from I to form a new training set I; Otherwise, directly execute step8;

Step 8: update training set I, $I\leftarrow I\cup P$, Using I to train DBN network model and update scheduling strategy;

Step 9: update the list of containers to be operated L. If all containers are completed, the dispatching results will be output; Otherwise, update the current time t and execute step 2.

2.1 Initial scheduling strategy

When the AGV reaches the idle state, the algorithm uses the scheduling strategy to select the appropriate job scheme for the AGV. The formulation of initial scheduling strategy directly affects the solution effect of the algorithm. Design heuristic rules as the initial scheduling strategy to complete the selection of AGV scheduling scheme. The steps are as follows:

Step 1: search from small to large according to the bank and bridge number. If the first task box in the shore bridge operation sequence is not arranged with an AGV, arrange the task box to the AGV and execute Step4; Otherwise, make k=2 and execute step 2;

Step 2: search from small to large according to the bank and bridge number. If the task box sorted as K in the shore bridge operation sequence is an export box and no AGV is arranged, arrange the task box to the AGV and execute Step4; Otherwise, execute Step 3;

Step 3: search from small to large according to the bank and bridge number. If there is a task box sorted as K in the shore bridge operation sequence and no AGV is arranged, arrange the task box to the AGV and execute Step4; Otherwise, make k=k+1 and execute Step 2;

Step 4: according to the stacking position of the ship / yard of the selected task box, select the shore bridge / yard exchange area with the shortest travel distance in the optional free exchange area. If there is no free exchange area, select the exchange area where the operation ends earliest;

Step 5: select the travel path with no increase in travel distance and minimum congestion coefficient for the AGV, and output the AGV scheduling scheme.

2.2 Training samples

After the scheduling strategy arranges the AGV operation scheme, the algorithm updates the strategy in real time before the next round of AGV scheduling. The optional scheduling scheme is evaluated by simulation with step size s, and a new training set is generated to update the scheduling strategy. For any scheme X in the optional scheme list, it is assumed that the AGV executes the scheme and continues to simulate the operation of s containers by using the current scheduling strategy. In order to facilitate the comparison between schemes, the operation completion time is converted into the average operation time of the shore bridge as the simulation evaluation value V (x):

$$V(X)=\frac{q}{n+s}(t_{n+s}-b),x\in Q$$

Where: q is the number of shore bridges; t_ (n+s) is the time after loading and unloading of n+s containers; B is the start time of the job, and Q is the set of optional scheduling schemes.

The algorithm compares the evaluation values of the scheduling schemes in the set Q, and obtains the simulation optimal scheme x*. Suppose the number of samples in set Q is p, then scheme x* is compared with the remaining optional schemes to generate P-1 positive training sets (scheme x* is in the front, the optional scheme is in the back, and the preference value is 1), and P-1 negative training sets (scheme x* is in the back, the optional scheme is in the front, and the preference value is 0).

The new training set and the initial training set are merged, and the DBN network model is input to update the scheduling policy in real time. With the accumulation of training sets, the influence of new training sets on model training decreases. To solve this problem, the algorithm updates the training set in real time. The updated initial training set and the new training set update the scheduling strategy together. If the number of samples in the initial training set is greater than the capacity of the standard training set C, C samples are randomly selected as the new initial training set, which is input into the DBN network model together with the new training set with the size of 2 (p-1); If it is less than C, the new training set and the initial training set are directly combined to complete the model training. With the continuous updating of the training set, the probability of the old samples remaining is getting lower and lower, which reduces the impact of the old samples on the update of the scheduling strategy and improves the operation speed of the algorithm.

3. Conclusion

The smart port logistics system is of great significance in promoting the construction of China's smart city in terms of intelligence, automation and information technology, as well as in terms of low cost, high reliability, energy conservation and environmental protection. It can be popularized and replicated for China's major port container terminals, and has very significant economic and social benefits. Aiming at minimizing the completion time of terminal operations, this paper constructs an AGV scheduling model, which comprehensively considers the task allocation and path planning selection in AGV scheduling, which helps to alleviate the congestion of AGV in the transportation process and improve the efficiency of terminal operations. According to the characteristics of the problem, an AGV real-time scheduling algorithm based on the preference function and DBN network model is designed. The preference function is used to arrange a reasonable job scheme for AGV, and the scheduling strategy is updated in real time by combining the real-time updated training set and DBN model.

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About the author:

Jiurong Fan(1978-), born in Jiujiang, Jiangxi Province, is a master candidate and lecturer. His research interests include automation and artificial intelligence.