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Intelligent RGV Dynamic Scheduling Strategy Based on Greedy Algorithm

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Abstract

In recent years, with the shortage of human resources and the increase in employment costs, the demand for intelligent processing system operations in various industries has increased. The smart car RGV can accept the command to automatically control the moving direction, distance and realize the loading and unloading work, which greatly solves the problem of workshop work cost and efficiency. In this paper, the greedy algorithm is combined with MATLAB [1], JAVA [2] and other languages. According to the different RGV different workshop operations requirements, the corresponding RGV dynamic scheduling model and algorithm are established. The analytic hierarchy process is used to evaluate the model. Consistency test, finally by consulting the literature, the improved model is based on genetic algorithm and K-Means++ RGV dynamic scheduling model to reduce the system imbalance caused by CNC failure and meet greater production needs. For the task, we can divide the RGV operation into two specific situations: RGV processing of materials in one process: By analyzing the RGV straight-track round-trip loading and unloading operation, we made the total time of loading and unloading of 8 CNC machine tools (CNC) as the optimization goal, aiming to use the most time in the loading and unloading process within 8 hours of continuous operation shift. The figure describes the RGV straight-track operation. By comparing the start time and RGV arrival time of each CNC, a dynamic scheduling model based on TSP algorithm is established, and the iterative conditions are satisfied. The corresponding planning model is written and written in JAVA. Solve. The first group can process 146 materials. The occurrence of RGV failure and the elimination of the processing effects on the first and second processes: From the title, the probability of failure and the time of troubleshooting are known. The faulty machine number within the range and the exclusion time are generated by the random function. The RGV optimal working path determined by questions one and two can be used to know the location of the faulty CNC number. By identifying the fault number by setting up the BAD FLAG, all the next path times including the item are sorted from big to small. When the BF mark appears at the next shortest target, the new value is removed after the minimum value is removed. The minimum value of the time series is the next rescheduling scheme; otherwise, the minimum value is still the scheduling scheme.

Keywords

Greedy algorithm; RGV dynamic scheduling strategy; AHP analytic hierarchy process; matlab; establishment of FLAG.

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1. BACKGROUND

1.1. Background Introduction

Rail Guided vehicle shorted as RGV, In real life, it is widely used in a variety of dense storage warehouses. The shuttle track of the vehicle can be infinitely long, usually with straight type, S-shaped curve and circular track. It has the characteristics of high speed, high reliability, low cost, etc. According to different functions, it can be divided into two types: assembly type RGV system and transportation type RGV system, mainly used for material transportation and workshop assembly. The circular orbital RGV system has high efficiency and can work with multiple vehicles at the same time. One RGV system in the reciprocating type of reciprocating only includes one RGV for reciprocating motion, and the cost is lower, and the efficiency is lower than that of the ring RGV. The RGV system can be used as a three-dimensional warehouse device or as a stand-alone system. It can be combined with the host computer or WMS system to realize automatic identification and access functions. At work, the algorithm can be designed to have the ability to move and load goods autonomously, effectively increase the storage density in the warehouse, and does not require large forklifts to enter, to ensure the safety during the operation. To ensure high efficiency and high flexibility of workshop production is the key to dynamic scheduling of workshop production. In the automation workshop, in order to improve work efficiency, workshop cost, how to solve the operational efficiency of the track-type smart car system (RGV) is a difficult problem.

1.2. Question Submitted

While controlling the cost of money and time, warehouses and workshops are working to improve the efficiency of loading and unloading goods and processing operations. The time cost includes the specified quantity of loaded and unloaded and processed goods that can be completed by the rail shuttle vehicle (RGV) within a specified operation period; the money cost refers to the number of RGVs included in an intelligent dispatch system, and the purchase cost and operation Required power costs and troubleshooting costs. Looking at the relevant information [1], we know that 95% of the time spent in the manufacturing process of the workshop is consumed in the non-cutting process. Therefore, how to balance the optimal efficiency and cost in the study of the optimal intelligent RGV scheduling scheme is A key issue in this article.

1.3. Research Significance

With the rapid development of automation technology, the use of intelligent warehouses (shops) has become extremely common. In view of the convenience and efficiency of intelligent RGV, its advantages are fully demonstrated in the automated production and processing lines and large warehouse logistics distribution centers in modern manufacturing. The development of e-commerce has emerged as a series of Internet industries such as Jingdong Taobao, and the warehouse needs to meet the needs of processing, packaging and distribution of goods. The intelligent warehousing of the manufacturing and processing industry combined with the automated production line can be used to complete the processing or other operations of a part of the complete set of products. In view of the above two operational requirements, by studying the dynamic scheduling scheme of intelligent RGV, it can significantly improve the efficiency of the enterprise and reduce the cost of production and processing, which is of great significance to the long-term economic development of the enterprise.

2. INTRODUCTION

1. Assume that in the first two cases in Task 1, all CNCs and RGVs have no faults during their work;

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2. Assume that the RGV travels at a constant speed during the movement (except for the RGV start, the brake time is staying);

3. Assume that the time that RGV puts back the unloaded conveyor after cleaning the finished material is negligible;

4. Different processes of the same workpiece cannot be processed at the same time, and there are successive constraints

5. Assume that after the processing is completed, the RGV arrives at the CNC to remove the clinker and immediately clean it in place.

6. The next working section is carried out after the cleaning is completed, regardless of the time it takes to put the material into the strip.

Symbol Description

Symbol	Symbol Description
t_i	The material on the i-th CNC can start processing time
x_i	The i-th CNC loading and unloading time
z_i	Current time
g_i	Time required for RGV to reach the i-th CNC
[i–j]	RGV time from the i-th CNC to the jth CNC
$\lfloor\ \rfloor$	Round down
i,j	CNC serial number that can complete the first process
$i^*,\ j^*$	CNC serial number that can complete the second process
$n_1,\ n_2$	the time to complete the first process and the time to complete the second process
n	Time required to process a process
h	Washing time
η	RGV work efficiency
M	The total number of materials processed by RGV in a single shift
S	Facing the flexible operation of RGV in case of failure, the number of completed materials in the case of no fault subtract the number of materials processed in the event of machine failure

The establishment and solution of the model

2.1. Pre-condition Preparation

2.1.1Noun Explanation

RGV

Rail Guide Vehicles is a rail-guided vehicle with intelligent control that can receive and send command signals autonomously. According to the instruction, it is possible to move and stop waiting on the linear track, the loading and unloading operation process, and the like.

Workshop flexible production

Workshop flexible production refers to the production of multi-process and multi-variety production methods mainly relying on highly flexible manufacturing equipment dominated by computer-controlled machine tools.

Machine tool flexibility

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The flexibility of the machine tool refers to the ability of the machine tool to adapt to the processing object, and can quickly transfer the production capacity from one product to another. The flexible manufacturing system is equipped with tools and equipment that are easy to disassemble and change, and the processing tasks are completed by quickly converting the processing tools. The conversion makes the cost of mixing multiple operations less than that of separate processing.

Robust scheduling

Robust scheduling refers to a scheduling scheme that takes into account predictable interference time based on known information and current operating conditions, or a part of predictable information, to ensure that the system's working efficiency is not affected by interference events. There are vicious fluctuations.

2.1.2 Principles

Efficiency

In the smart RGV straight-track round-trip operation, we define a "distance" - the sum of the time of the next destination and current location that RGV is about to reach and the time required to perform the job after arriving at that destination. We try our best to make the RGV driving a specified destination CNC and the corresponding job task under each decision. The sum of the time corresponding to the two is better than other CNCs. Every decision execution is toward the current state. The highest, best one CNC implementation. Under this principle, it is possible to avoid the RGV meaningless round-trip travel during the course of other processing tasks, or the machine cost consumed by the process in place.

Practicality

To solve the problem of dynamic scheduling of intelligent processing systems, it is necessary to focus on the actual situation, solve the scheduling problems in line with the actual production, try to make the program universally applicable, and can be put into the actual production workshop to achieve quick and convenient use. Save costs and increase operational efficiency.

3. PROPERTIES

3.1. Simulate A Simple RGV Roadmap

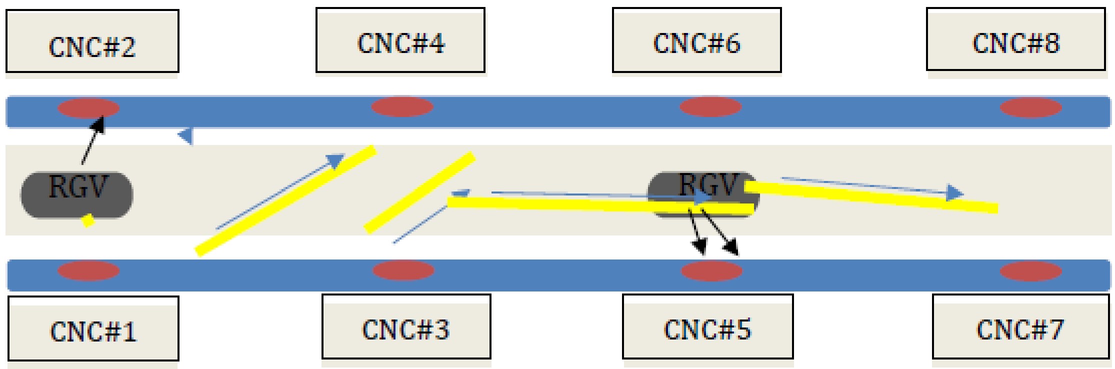

Figure 1. Simulate a simple RGV roadmap

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Table 1. Roadmap symbol description

symbol	Symbol description
	RGV's two robot arms
	Material to be processed
	RGV operation route

3.2. Processing A Process Material Scheduling Strategy Solving Model

3.2.1 Model analysis

STEP1:

The optimization goal is to make the optimization target within the eight hours of one operation time to be within eight hours of one operation time, so that the total time of multiple loading and unloading is the longest in the operation process, so as to achieve the maximum efficiency utilization operation time. X_i is a single loading and unloading time, and for different numbered CNCs, x_i has two different values, 28 and 31 respectively. The total loading and unloading time is the longest to achieve maximum efficiency utilization time. X_i is a single loading and unloading time, and for different numbered CNCs, x_i has two different values, 28 and 31 respectively.

$$\max \mathrm{m} = \sum x_i \tag{1}$$

$$x_i = \begin{cases} 31, & 2|x_i \\ 28, & 2|x_i \end{cases} \quad (\text{"|"refers to be devisible}) \tag{2}$$

STEP2:

Determine the rigid constraints, the problem requires 8 hours of continuous operation per shift. We use 8 hours as a work cycle. The current time z_i initial time z_i=0 is set, and the current time is accumulated up to 8 hours. Let g_j be the travel time of the smart RGV to the jth CNC, including the time required for the previous i-th CNC loading and unloading time and the RGV to travel from the i-th CNC position to the j-th CNC. The initial state has no previous state of loading and unloading, so g_j is only the driving distance from the first CNC at the initial position to the other seven positions, as shown below:

$$g_1 = g_2 = 0 \tag{3}$$

$$g_3 = g_4 = 20 \tag{4}$$

$$g_5 = g_6 = 33 \tag{5}$$

$$g_7 = g_8 = 46 \tag{6}$$

$$\sum_{j=1}^{\infty} z_j \leq 8 \times 3600 \tag{7}$$

From then on, we will define the time required to travel from the RGV from the i-th CNC position to the j-th CNC.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201909_5(9).0031

$$[\mathrm{i-j}] = \left\lfloor \frac{|i-j|}{2} \right\rfloor$$

$$= \begin{cases} \frac{1}{2}, 0 \\ 1, 20 \\ 2, 33 \\ 3, 46 \end{cases} \quad (8)$$

STEP3:

According to the above-mentioned t_i and g_i values and their intrinsic connection, by comparing the "distance"g_i between the current position i and the next decision position j with the startable processing time t_j, i of the next decision, 1.2...8 is taken. In order to ensure that the process end signal is issued at the jth CNC, the RVG advances to the next decision j-th CNC in advance and immediately performs the loading and unloading operation at the same time as the signal is sent, so the maximum values of g_i and t_i are taken. Considering that the processing time corresponding to the CNC arriving at different positions is different, the sum of the above two sums is taken, and the minimum value of i=1.2...8 is taken to determine the number j of the next decision CNC, saving time cost and avoiding unnecessary on the way. Round trip and waiting time

$$z_j = \min_{1\le i,j\le 8} \{max\{t_i, g_i\} + x_i\} \quad (9)$$

To STEP4

STEP4:

After determining the CNC position j of the next decision of RGV, after the loading and unloading timex_i is finished, a process of machining is required, and the processing time is n=560. The next time the CNC can start the machining time t_i at the position must be completed. To start the next processing, there is an iteration equation about the start timet_i:

$$t_j = t_j + n \quad (10)$$

To STEP5

STEP5:

During the loading and unloading process of the j-th CNC, the process of waiting for the loading and unloading, and the washing time after the completion of the first process will affect the RGV arrival timeg_i of the other seven CNCs except the ongoing j-th CNC. If $g_i \geqslant t_i$, this indicates that when the i-th CNC ends the previous process, it is not possible to start the next process immediately because of the time limit of the "distance".g_i = g_i + [i-j] + h + x_i- t_i. In the other case, when $g_i < t_i$, the next process start time depends on t_i, then g_i = g_i.

$$g_i = g_i + w_i \quad (11)$$

$$w_i = x_i + h + [\mathrm{i-j}] \quad (12)$$

$$w_i = \begin{cases} 0 & , \ g_i < t_i \\ x_i + h + 【\mathrm{i-j}】 - t_i & , \ g_i \ge t_i \end{cases} \quad (13)$$

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Model building and solving:

MAX$\sum x_i$

$$
\begin{cases}
\sum_{j=1}^{\infty} z_j \le 8 \times 3600 \\
z_j = \min_{1\le i,j\le 8}\{max\{t_i, g_i\} + x_i\} \\
t_j = t_j + n \\
g_i = g_i + w_i \\
x_i \begin{cases} 31, & 2|x_i \\ 28, & 2|x_i \end{cases} \quad (\text{“|”refers to be devisible }) \\
t_i = 0\,, \mathrm{n} = 560 \\
g_1 = g_2 = 0 \\
g_3 = g_4 = 20 \\
g_5 = g_6 = 33 \\
g_7 = g_8 = 46 \\
w_i = x_i + h + 【\mathrm{i}-\mathrm{j}】 \\
w_i = \begin{cases} 0 & , \quad g_i < t_i \\ x_i + h + 【\mathrm{i}-\mathrm{j}】 - t_i & , \quad g_i \ge t_i \end{cases} \\
【\mathrm{i}-\mathrm{j}】 = \left[\frac{|i-j|}{2}\right] = \begin{cases} \frac{1}{2}, 0 \\ 1，20 \\ 2，33 \\ 3，46 \end{cases} \\
\mathrm{i}, \mathrm{j} = 1.2 \ldots 8
\end{cases}
$$

3.2.2 Establish a rescheduling model under predictable failure mechanism

Task Analysis:

The CNC may malfunction during the machining process, and the probability of occurrence of the failure is about 1%. The probability of occurrence of the failure of the loading and unloading process in the first working cycle is the number of failures in one working cycle. Every time troubleshooting, manual processing, unfinished material scrapping, that is, restarting and restarting new material processing, the time is between 10~20 minutes, and the operation sequence is added immediately after troubleshooting. [4] Under the event of predictable failure, the rescheduling mechanism of the failure mechanism is established, so that the entire processing system is minimized by the efficiency risk of the failure mechanism.

Model establishment: Using a random function to construct a value within a reasonable range, the specific CNC number value can be obtained, and then according to the first and second questions, the RGV can complete the RGV working path with the largest number of loading and unloading in the specified working cycle, and The specific time (in seconds) at which a specific fault occurs. From the title, the probability of failure and the time of troubleshooting are known. The faulty machine number and exclusion within the range generated by the random function. By identifying the fault number by setting up the BAD FLAG, all the next path times including the item are sorted from big to small. When the BF mark appears at the next shortest target, the new value is removed after the minimum value is removed. The minimum value of the time

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series is the next rescheduling scheme; otherwise, the minimum value is still the scheduling scheme.

4. TESTS

This paper uses AHP (Analytic Hierarchy Process) to determine the decision-making factors: RGV's work efficiency η, the total number of materials completed in a single shift, and the importance weight of the flexible work situation S of the RGV in case of failure, and then build the evaluation index. K analyzes and evaluates the scheduling strategy model, and judges the robustness of the scheduling strategy and the most suitable processing mode to prepare for the next optimization.

Analytic Hierarchy Process Analysis:

AHP (Analytic Hierarchy Process) Analytic Hierarchy Process (AHP) is a practical multi-objective decision-making method proposed in modern times. It is also a decision-making method combining quantitative and qualitative. Using AHP can get the weight of the importance of different decision factors, and provide a strong basis for decision-making.

Building a hierarchical model The goal of the decision (the most suitable processing mode for the strategy), the decision factors considered (the efficiency of the RGV, the total number of materials completed in a single shift, and the robustness in the face of failure) and the decision to process a single shift The total number of materials and the robustness objects (two processing modes) in the face of failure are layered according to their mutual relationship, and the hierarchical structure of the figure (2) is drawn.

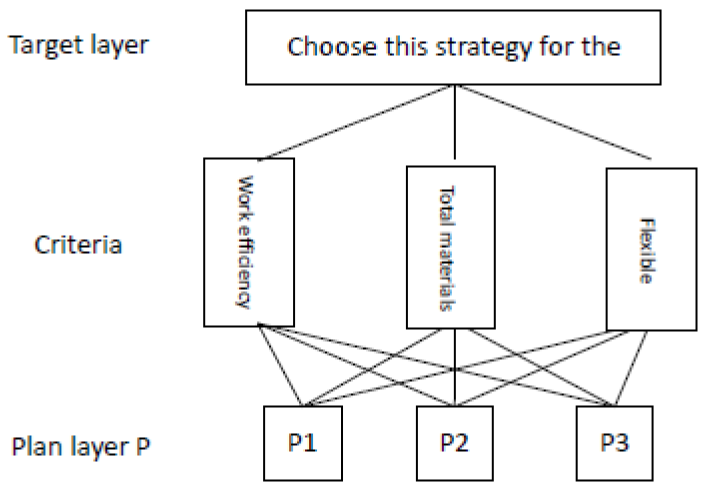

Figure 2. Hierarchical relationship diagram between layers

Building a judgment matrix

In determining the weights between the levels, the consistent matrix method is used, which uses relative scales to compare all decision factors in pairs, thereby reducing the difficulty of comparing different factors and improving the accuracy.

Let the three decision factors be a1: RGV work efficiency; a2: the total number of materials processed in a single shift; a3: the robustness in the face of failure. The judgment matrix is obtained as follows:

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$$A = \begin{pmatrix} 1 & 7 & 3 \\ \frac{1}{7} & 1 & \frac{1}{5} \\ \frac{1}{3} & 5 & 1 \end{pmatrix} \tag{14}$$

(1) Judging the maximum eigenvalue of the matrix and the corresponding eigenvectors

Each column of the matrix is normalized,

$$B_{ij} = \frac{A_{ij}}{\sum A_{ij}} \tag{15}$$

The normalized matrix is summed by row,

$$\overline{W} = (\overline{W_1}, \overline{W_2}, L, \overline{W_n})^T \tag{16}$$

Normalize the vector

$$W_i = \frac{\overline{W_i}}{\sum \overline{W_i}} \tag{17}$$

Calculate the maximum eigenvalue

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(BW)_i}{nW_i} \tag{18}$$

Judgment matrix consistency test

$$CI = \frac{\lambda - n}{n-1} \tag{19}$$

When CI = 0, A is consistent;

The larger the CI, the more serious the inconsistency of A.

Random consistency indicator RI

Table 2. Random consistency indicators (RI)

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Consistency ratio (allowed range for determining the inconsistency of A)

$$CR = \frac{CI}{RI} \tag{20}$$

When CR < 0.1, the degree of inconsistency of matrix A is acceptable, and the weight vector is the eigenvector of A.

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REFERENCES

[1] Sun Xiang, "MATLAB7.0", Tsinghua University Press, 2013.

[2] Li Xinghua, "JAVA Development Combat Classic", 2009.

[3] Liu Yongqiang, Zhang Dong, et al., Research on Dynamic Scheduling Based on Genetic Algorithm, 2012.

[4] He Haiyang, “Analysis of Job Shop Scheduling Considering Machine Fault Characteristics”, China Three Gorges University, 2015.