

Study on Optimizing Dynamic Scheduling of Intelligent RGV

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Abstract. Firstly, under known conditions, the dynamic scheduling model of RGV intelligent vehicle is established by analyzing the process under different processing conditions. Through this model, the optimal route and the shortest time for RGV intelligent vehicle to respond to CNC of NC machine tool in material processing are obtained. At the same time, RGV scheduling strategy and system operation efficiency are given. For the material processing operation of a process, each CNC is equipped with the same cutting tool, and the material can be processed on any CNC. According to the Dijkstra algorithm in the shortest path and the first-come-first-service scheduling algorithm, the first case can be simulated and analyzed. The optimal route and the shortest time between RGV and each CNC can be obtained. According to the two algorithms, the dynamic scheduling model in this case can be reflected by C++ programming, and then the qualitative analysis can be made to obtain the results of processing data of a process in one shift at this time. For the material processing operation of two processes, the first and second processes of each material are processed by two different CNCs in turn. According to hypothesis validation, in the case of two working procedures, eight CNCs are allocated reasonably to two different cutting tools in different order to find out the optimal allocation method, and through this allocation method, the same algorithm is adopted as in the first case, and then the qualitative analysis is made to obtain the data results of the two working procedures in one shift at this time. For the case that CNC may fail in the process of processing, we can reduce the number of faults according to the rescheduling strategy and the job shop scheduling algorithm, simplify the complexity, and then combine the results of the previous processing with the two models established before in two different situations to get two sets of different data.

Keywords: Dynamic scheduling, shortest path, Dijkstra algorithm, first serves, C++ programming, rescheduling strategy.

1. Introduction

With the development and progress of information technology, control engineering, mechanical engineering and other technologies, intelligent processing system is becoming increasingly unmanned, automated and intelligent, which significantly improves the efficiency of industrial processing, logistics services and other work. Researchers at home and abroad use the fuzzy classification algorithm to find out the probability of the tasks to be generated, then consider the existing tasks and the tasks to be generated, and use genetic algorithm to assign RGV delivery more reasonably. Perhaps a standardized automated three-dimensional warehouse model with circular conveying system is constructed by using colored timed Petri nets. The utilization ratio of RGV and stacker under six scheduling strategies is compared, and the scheduling strategy with the highest utilization ratio is selected. These scheduling strategies can dispatch shuttle trucks more reasonably, improve the operational efficiency of RGV system, and further promote the development of intelligent processing system.

2. Model Establishment and Model Solution

2.1 Modeling and Model Solution in Material Processing Operation of One Procedure

2.1.1 Model Establishment

(1)First of all, we should check whether there is clinker that has been processed before all 8 CNCs are finished in the feeding stage.

According to all the data given in Table 1, it is assumed that the feeding has been completed in CNC1, and then the processing begins in CNC1, according to the contents of the table:

The minimum time required to complete a process from three sets of data, i.e. $f_{\min} = 545s$;

Take the maximum value of $C_{\max} = 35 / 2 = 17.5s$ for the completion of one feeding process; (the longest time of one feeding and unloading is 35s);

Make the maximum distance of each movement, that is, the maximum distance of three units per movement is $T_3 = 59s$;

Assume the longest time after the last CNC completes feeding be T_{\max} :

$$T_{\max} = 7 \times (C_{\max} + t_3) = 7 \times (17.5 + 59) = 535.5s$$

$$T_{\max} \leq f_{\min}$$

Therefore, it is concluded that there is no clinker that has been processed before all 8 CNCs are finished in the feeding stage. That is to say, only when 8 CNCs have completed the first stage, can they start the second stage.

(2)Next, through Dijkstra algorithm (shortest path algorithm) [1], and first come first service scheduling algorithm [2], RGV responds to a CNC that sends out a request signal, establishes RGV dynamic scheduling model, and designs the optimal scheduling process of this dynamic scheduling model through C++ program in the programming environment of CodeBlocks software.

Collecting system information, starting to judge the stage, the charging stage is S1, the loading and unloading stage is S2, if the starting stage is S1, then according to some CNC send demand signals, assuming the number of nodes is n, the current RGV location is origin 0.

The specific steps of the algorithm are as follows:

(1) Initialization, let CNC1# to CNC8# be v1, v2, v3, v4, v5, v6, v7, V8 respectively, and set $d(0) = 0$ at the starting node, $D[i]$ represents the distance from RGV to CNC.

(2) loop solution: let I do n-1 cycle, update the distance of the node arrived by the node through a CNC, and update the shortest path information that can be reached by the node without access to CNC. ‘e’ represents the weight, and the cycle is completed until all the nodes without access are completely processed.

(3) The shortest path to termination node t: Dijkstra algorithm is used to extract the optimal path step by step: $D[i] = arcs[LocateVex(G, v)][i], v_i \leq v$.

Using the first come first serve algorithm, K is the priority, and K is the initial value of zero, C is the timer, when the weight is the same, $K = 1$, the minimum CNC of the timer is executed first to cycle n-1 times. Until the shortest path is found.

The flow chart of the algorithm is shown below.:

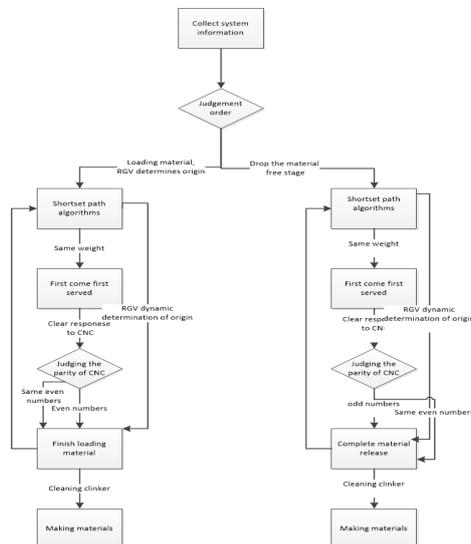


Figure 1 Flowchart of algorithm

(3) According to the process analysis of the above algorithm, the optimal scheduling strategy is obtained, as shown in the following figure.

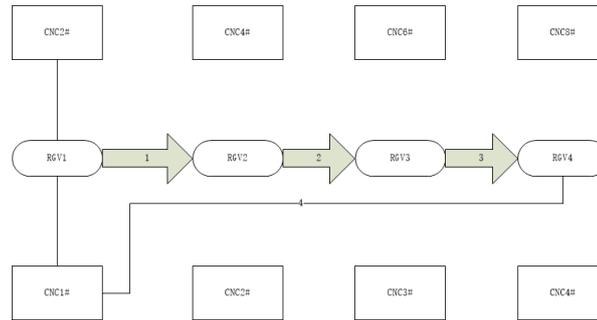


Figure 2 Optimal scheduling process

2.1.2 Model Solution

(1) According to Figure 2, the optimal scheduling strategy of RGV in the case of material in one process is 0.1-0.2-0.3-0.4, when RGV is in the case of eight CNCs, the sequence of the first cycle of the whole small system is CNC1-CNC2-CNC3-CNC4-CNC5-CNC6-CNC7-CNC8-CNC1.#

(2) Operation efficiency E1 of the system

$$E_1 = \frac{T_1}{T_2} = \frac{T_1}{T_1 + T_4} = \frac{T_1}{T_1 + T_3} = \frac{681}{681 + 18} = 97.42\% \tag{1}$$

Note: Formula (1) T₁ denotes the working time of the system; T₂ denotes the total time of the system; T₃ denotes the failure time; T₄ denotes the waiting time.

So the operating efficiency of the system is 97.42% in the case of material in one process.

(3) According to CodeBlocks software, C++ program can be compiled to solve the problem. See Appendix 1 (source file is Annex 1.1). Through the program, the optimal RGV scheduling strategy and system operation efficiency can be obtained, and then three different groups of specific results can be calculated respectively. See the EXCEL table in Annex 2.

2.2 Model Establishment and Model Solution in Material Processing of Two Processes

2.2.1 Model Establishment

Because the proportion of time in the feeding stage is too small for 8 consecutive hours, in this problem, it is assumed that during the whole processing process, each CNC always has material, that is to say, the material scheduling in the continuous operating time is the feeding and unloading process:

Because there are seven different situations for distributing A.B two different blades in eight CNCs {A1B7, A2B6, A3B5, A4B4, A5B3, A6B2, A7B1}, it is assumed to analyze one situation first, that is, to allocate four A and four B cutters to eight CNCs; assuming that through statistical analysis and comparison, the optimal distribution of blades under the condition of A4B4 is ruled out step by step as follows: when the odd number of CNC machine tools is the same kind of blades, CNC machine tools are the same type. Even number of bed blades of the same kind.

Then according to the Dijkstra algorithm (shortest path algorithm) and the first come first service scheduling algorithm, RGV responds to a CNC that sends a request signal, establishes the RGV dynamic scheduling model, and designs the optimal scheduling process of the dynamic scheduling model in the programming environment of CodeBlocks software through C++ program. (See 112 above for details of the algorithm). The optimal scheduling strategy is obtained. As shown in the following figure:

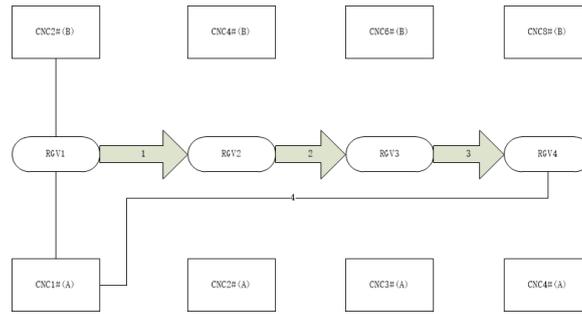


Figure 3 Optimal scheduling process

2.2.2 Model Solution

(1) According to Figure 3, the optimal scheduling strategy of RGV under A4B4 is 0.1-0.2-0.3-0.4, when RGV operates on eight CNCs, the sequence of the first cycle of the whole small system is CNC1 CNC2 CNC3 CNC4 CNC5 CNC6 CNC7\ CNC8\ CNC1.#.

(2) The operating efficiency of the system at this time E_1

$$E_1 = \frac{T_1}{T_2} = \frac{T_1}{T_1 + T_4} = \frac{T_1}{T_1 + T_3} = \frac{681}{681 + 20} = 96.87\%$$

So, the operating efficiency of the system is 96.87% in the case of material in the second process.

(3) According to CodeBlocks software, C++ program can be compiled to solve the problem. See Appendix 2 for the source file (Appendix 1.2). Through the program, the optimal RGV scheduling strategy and system operation efficiency can be obtained, and then three different groups of specific results can be calculated respectively. See the EXCEL table in Appendix 2.

2.3 Model Establishment and Model Solution of Material Processing Operation in One and Two Processes in Case of Failure

2.3.1 Model Establishment

(1) Assume first according to the meaning of the question.

t_{eih} :Waiting time before the first h process of group i data starts processing;

T_{ih} : Processing start time of the H process for group i data;

O_i : Group i Data Two Processes First Procedure

$$P_{ijx} = \begin{cases} \text{The first of two processes for group i data, } x=f \\ \text{A procedure for group i data, } x=s \end{cases}$$

$$Y_{ijx} = \begin{cases} 0 & O_{xi} \text{ is unaware that device } m_j \text{ is executing, } x=f,s,c \\ 1 & O_{xi} \text{ is performed on the device } m_j, x=f \\ 1 & O_{xi} \text{ is performed on the device } m_j, x=s \\ 1 & O_{xi} \text{ is performed on the device } m_j, x=c \end{cases}$$

DT is troubleshooting time = fault occurrence time + fault repair time

t_{ix} : Processing Start Time of Procedure X of Group I Data, $x=f, s, c$

$$D_e = \begin{cases} 0 & \text{The operation time will not be affected before the failure occurs} \\ D_t & \text{The fault occurs during processing, which affects the working time and requires waiting} \end{cases}$$

(2) Rescheduling to get flow chart, as shown in the following figure:

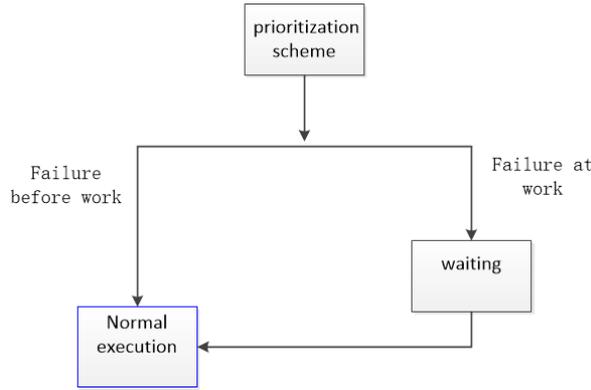


Figure 4 Rescheduling flow chart

(3) Threshold Judgment

Using the ratio of the fault delay time to the working time of the current process to determine whether L_d needs to be rescheduled.

$$L_d = \frac{D_e}{P_{ijx}}$$

(4) Efficiency of Job Scheduling Strategy

Completion time is one of the most basic criteria for measuring scheduling strategy, and also one of the important indicators for job shop scheduling research. The shorter the maximum completion time, the higher the efficiency of scheduling strategy and the minimization of maximum completion time.

$$C_{max} = \text{Max}(T_{ih} + P_{ijx}), i = 1, 2 \dots m; x = 1, 2 \dots X_i$$

(5) Minimum delay time

$$We_{max} = \sum_{j \in ih, j=1, 2 \dots n, h=1, 2 \dots X_i}$$

(6) Unification

$$F = \text{Min}(\omega_1 C_{max} + \omega_2 We_{max})$$

$$\omega_1 + \omega_2 = 1$$

The constraints in the scheduling process are as follows:

$$\sum_i Y_{ijx} \times P_{ijx}, i = 1, 2 \dots m; x = 1, 2 \dots X_{j-f-s}, X_{j-f-s+1} \dots X_j \tag{2}$$

$$t_{ix} + 1 \geq t_{ix} + P_{ijx} + te_{ih}, i = 1, 2 \dots n; j = 1, 2 \dots m; x = 1, 2 \dots X_{j-f-s}, X_{j-f-s+1}, X_j \tag{3}$$

$$\sum_i Y_{ijx} = 1, i = 1, 2 \dots n; j = 1, 2 \dots m; x = 1, 2 \dots X_{j-f-s}, X_{j-f-s+1} \dots h_j \tag{4}$$

$$Y_{ijx} \in [0, 1], i = 1, 2 \dots n; j = 1, 2 \dots m; x = 1 \dots X_{j-f-s}, X_{j-f-s+1} \dots X_j$$

$$t_{ix}, P_{ijx} \geq 1, i = 1, 2 \dots n; j = 1, 2 \dots m; x = 1, 2 \dots X_{j-f-s}, X_{j-f-s+1} \dots X_j$$

Note: Formula (2) denotes the processing time of raw meal in the processing equipment, Formula (3) denotes the starting processing time of the next process of raw meal, Formula (4) denotes that each CNC can process at most one raw meal at any time.

(7) According to the optimal path model established before, the RGV scheduling strategy and system efficiency of material processing operation in one and two processes are worked out respectively.

2.3.2 Model Solution

According to a given three sets of data parameters, an example of job scheduling for three processes of each set of data on three CNCs is given. The processing sequence and processing time of each raw material on CNC are given in the table.

(1) The average material processing time of these three groups of processes is about 561 seconds on CNC. At this time, the optimal routing sequence of material processing in one process is: CNC1-CNC2-CNC3-CNC4-CNC5-CNC6-CNC7-CNC8-CNC1.#;

(2) The average processing time of materials on CNC is 428 seconds in the first process and 439 seconds in the second process. At this time, the optimal sequence of material processing in the second process is: CNC1 CNC2 CNC3 CNC4 CNC5 CNC6\ CNC7\ CNC8\ CNC1.#;

(3) The operating efficiency of the system during material processing in one process is E_1 :

$$E_1 = \frac{T_1}{T_2} = \frac{T_1}{T_1 + T_4} = \frac{T_1}{T_1 + T_3} = \frac{681}{681 + 18} = 97.42\%$$

(4) The operating efficiency of the system during material processing of two processes is E_1 :

$$E_1 = \frac{T_1}{T_2} = \frac{T_1}{T_1 + T_4} = \frac{T_1}{T_1 + T_3} = \frac{681}{681 + 20} = 96.87\%$$

(5) According to CodeBlocks software, C++ program can be compiled to solve the problem. The specific source files of the program can be found in Appendix 1 and Appendix 2. Through the program, three different groups of specific results can be calculated, respectively, as shown in the EXCEL table of Appendix 2.

3. Summary

3.1 Advantages and Disadvantages of Model

In the case of material processing operation in a process, the model is mainly established by Dijkstra algorithm (shortest path algorithm) and first-come-first-service scheduling algorithm. In the programming environment of CodeBlocks software, a large number of data results are obtained through C++ programming. In this algorithm, program scheduling can obtain more accurate values. But the procedure is too large and there are too many uncertainties.

In the analysis of material processing operation in two processes, the model is mainly based on two hypotheses. Through these two hypotheses, the complex problem of material processing with uncertain number of cutters and location is transformed into two problems of material processing based on the optimized position of CNC, which makes it not particularly complicated even under the conditions of two processes. It is trivial, so it is easier to get the result in the optimization algorithm with higher accuracy. But there may be some errors in these two assumptions.

In the case of failure, the rescheduling strategy is used to reduce the algorithm, which makes the algorithm simpler and can be used as job shop scheduling algorithm to simplify the complexity and achieve accurate results. However, the rescheduling strategy algorithm used in this problem can only calculate a single factor, not multiple factors. Job shop scheduling problem is often only a single objective problem, and can not flexibly calculate multiple objectives.

3.2 Expectation

In view of too many uncertainties in the model of material processing operation in one process, SPSS software can be selected to display and solve the established model in SPSS in the form of algorithm, so as to avoid the disadvantage of too high error rate of the program; in view of the model of material processing operation in two processes, assuming that the error is too large, it can be solved by neural network model and genetic algorithm. In order to narrow the error range, the algorithm can be solved by dynamic scheduling strategy to improve the efficiency of analysis. When the direction is changeable and the problem is multi-objective, the hybrid ant colony algorithm can be used to calculate it.

References

- [1]. Weimin Yan, Weimin Wu. Data Structure [D]: Tsinghua University Press, 2016.12.
- [2]. Xiaodan Tang, Hongbing Liang, Fengping Zhe, Ziyang Tang. Computer Operating System 4th Edition [D]: Xi'an University of Electronic Science and Technology Press, 2016.12.
- [3]. Tian Long. Production scheduling optimization in intelligent manufacturing [J]: Master's thesis, Southwest University of Science and Technology, 2013.
- [4]. Songtao Yan. Research on production scheduling under personalized customization [J]: Master's thesis of Southwest University of Science and Technology, 2017.
- [5]. Haoqiang Tan. C++ Programming [D]: Tsinghua University Press, 2016.12.
- [6]. Wentao Liu. Mass customization-based rescheduling [D]: Social Sciences Literature Publishing House, 2008.
- [7]. Bing Li, Jing Wang, Xingsheng Gu. Multi-objective Job-shop dynamic scheduling based on improved ant colony algorithm [D]: Journal of East China University of Technology (Natural Science Edition), 2015.
- [8]. Dajuan Wang. Models and algorithms for rescheduling interference in production scheduling [J]: Ph.D. Dissertation, Dalian University of Technology, 2015.
- [9]. Qingcheng Zeng. Integrated Dispatching Model and Method for Container Terminal Handling Operation [J]: Ph.D. Dissertation, Dalian Maritime University, 2008.
- [10]. Shoukui Zeng, Xijing Sun. Mathematical Modeling Algorithms and Applications [D]: National Defense Industry Press, August 2011.
- [11]. Xiaoyin Wang, Baoping Zhou. Mathematical Modeling and Mathematical Experiments [D]: Science Press, 2010.1.