

Scheduler of CNC-RGV System based on STFF Model

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Abstract. To improve the working efficiency of RGV-CNC processing system, we develop a smart model which have the function of predicative controlling and receding horizon. It can be universally applied to the situation which contains one or more processes. We use Genetic Algorithm to optimize the workflow and obtain successful results.

Keywords: RGV-CNC, a smart model, Genetic Algorithm.

1. Introduction

A processing system is consisted of several computer number controllers, for short CNC, one rail-guide vehicle, simply as RGV, one RGV rail as well as two conveyer belts.

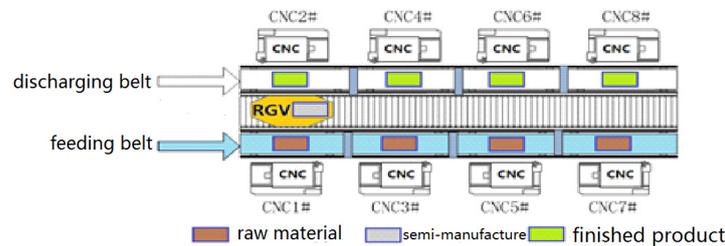


Figure 1. RGV-CNC processing system

RGV is an unmanned intelligent car moves on a particular rail. It can change direction (forward or backward) as well as distance by the order of console. And there is a manipulator on it, which is used to discharge, feed and ,of course, wash the product.

In the system, RGV decides the priority of several CNCs on the basis of messages from CNC. We suppose that there are in total 8 CNCs on two sides, and RGV can move among 4 positions freely. The figure below describes the workflow of RGV-CNC system.

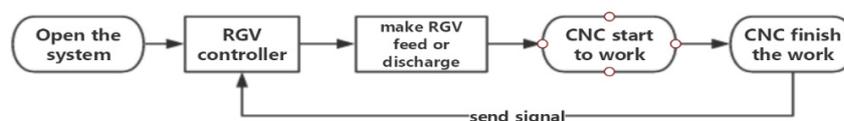


Figure 2. workflow of RGV-CNC processing system

The target of our study is to get the largest number of the finished products during 8 hours.

2. STFF Model

Shortest Seek Time First, simply as SSTF, is a widely-used disk dispatch algorithm: When a process is selected by this algorithm, the Shortest Seek Time is required to be the shortest distance between the track it accesses and the track where the current head is located[1], which is very similar to the "request-response" mechanism of RVG-CNC. Based on this, we compared the scheduling of RGV-CNC system with disk scheduling.

Next, we will consider the specific working condition of CNC: when one CNC is idle or has finished machining, it will send a request signal to RGV, however, there may be more than one CNCs that will send request in the same chip. Therefore, it is unable to meet the requirements of high efficiency when we simply arrange the rank of CNC according to the sending signal, CNC ordered by optimal priority.

2.1 Modeling Analysis

For the reasons above, jobs that may be delayed need to be identified and dynamically adjusted for execution. The service sequence is defined as $Z=\{Z_i|i \in [1, n]\}$, and n is the number of waiting services. We can reflect the possibility of service delay by “urgent value“ of service demand, namely, the urgent value J is reflected by its completion degree of material, the higher the urgent value is, the larger the urgent value is, so as to quantify the urgent degree of a CNC for service (i.e. feeding or unloading).The completion degree of materials depends on the following three aspects:

t_1 : the remaining time between material processing and completion

t_2 : the time required for the RGV to move to the specified location

t_3 : loading and unloading and cleaning time (t_3 is known and fixed for a specific set of parameters)

According to the shortest seek time priority algorithm, the weight of time are equal, so we can draw their complete degrees ω :

$$\omega = \frac{1}{t_1 + t_2 + t_3} \tag{1}$$

When RVG receives multiple requests, it will form a service queue. When there are large number of requests stuck in the queue, CNC with high urgent value should be given priority of service, so as to release resources as soon as possible and alleviate the pressure[2]. The expression of the pressing value is:

$$J = \omega \tag{2}$$

As can be seen from the above formula, the longer the corresponding time is, the longer the task can wait, so the corresponding pressing value J is also smaller, which means that RVG can delay the response to this request.

The algorithm flow of generating the maximum number of jobs is as follows:

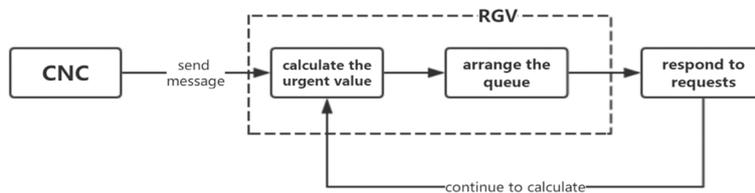


Figure 3. The algorithm processes

2.2 Model Building

In signal analysis, we can find the descriptions of mutual correlation function and auto-correlation function. The auto-correlation function describes the correlation degree of random signal $X(t)$ between the values of $t1$ and $t2$ at any two different moments. The cross-correlation function gives an index to judge whether two signals are correlated or not in the frequency domain. It can be used to determine how much of the output signal comes from the input signal and is extremely effective in correcting errors due to noise sources being plugged into the measurement [3].

Similarly, in the intelligent system, there are 8 CNC in total. According to the signal analysis theory, the pressing value of each CNC machine is not only related to its own situation, but also affected by all the other 7 machines. For a CNC, its autocorrelation is only related to the time required for RVG to respond to requests, and its cross-correlation is complex. When the RGV moves to a certain position, the autocorrelation of all CNC will change. These changes in the amount of autocorrelation will have an impact on the CNC currently studied.

We consider that, in order to ensure the total working efficiency of CNC over a period of time, RGV should give priority to the request from the CNC that produces the maximum efficiency.

According to the definition in RMMS model, RGV will respond to the CNC that holds the maximum urgent value.

The influence of other 7 CNC machines on the currently selected CNC is reflected in the change in the autocorrelation, which is related to the predetermined position of the RVG. In other words, at every decision moment of the RVG, the change in the control effect should be recalculated according to the current estimation, and the rolling calculation should be carried out continuously. The optimization we do is not done offline once, but repeatedly online as the moment progresses. Therefore, considering the amount of cross-correlation is actually a kind of Predictive Control (MPC) as well as rolling optimization (RH) process. This process should be described through our flowchart:

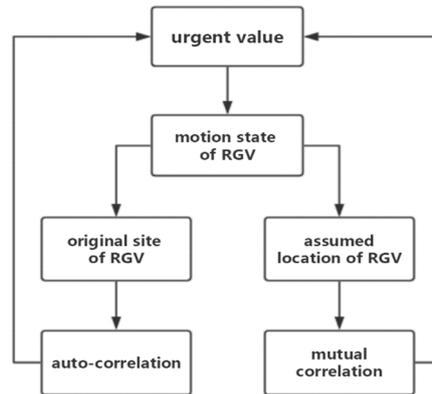


Figure 4. The flowchart of urgent value

Then we define the auto-correlation (G_a) and cross-correlation (G_m) of a CNC:

$$G_a = t_1 + t_2 + t_3 \quad (3)$$

$$G_{mi} = \frac{1}{\sum_{j=1}^8 \frac{k_{ij}}{G_{aij}}} \quad I, j \in \{1, 2, 3, 4, 5, 6, 7, 8\} \quad (4)$$

According to the algorithm mentioned above, we can give the following equation:

$$G_{aij} = t_{j1} + t_{j2} + t_{j3} \quad (5)$$

Among these:

I represent the number of CNC currently selected;

J stands for other CNC Numbers;

K is for cross correlation.

In particular, the cross-correlation k of CNC is 0:

$$k_{ij} = \begin{cases} 0 & (i = j) \\ a & (i \neq j) \end{cases} \quad (a \neq 0) \quad (6)$$

Therefore, combining with equation (1), we can deduce the expression of the new urgent value J:

$$J = \omega + \frac{1}{G_{mi}} \quad (7)$$

According to different situations, the value of k will change. According to the problem analysis, in this case, what we need to consider is to obtain the maximum material production, so the Genetic Algorithm (GA) can be used to optimize k, so as to obtain the ideal cross-correlation.

3. Calculation and Verification

According to the above model, we first used genetic algorithm to optimize k. And we can obtain the maximum production of the following three groups as shown in figure 5 (corresponding to three groups of parameters respectively).

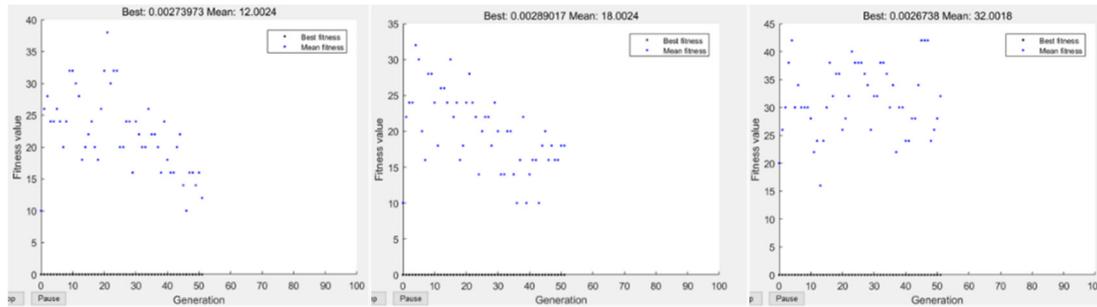


Figure 5. maximum production based on genetic algorithm

After the optimal values of k are obtained by genetic algorithm, they are substituted into the expression (7) to obtain the theoretical expression of the urgent value J. Then, each time the RGV judges the request response, the specific urgent values of 8 CNCs are worked out according to the rolling optimization model, and the service queue is arranged according to the urgent value, so that the request issued by the highest ranked CNC in the RGV response queue can be obtained.

Table 1. Simulation results

group	The theoretical maximum	K1	K2	K3	K4	The actually output value	Working efficiency
Group one	374.9412	69.31	263.815	276.370	52.836	357	95.21%
Group two	358.6074	4.765	289.505	280.165	11.4046	338	94.25%
Group three	384.3270	5.685	75.189	75.189	80.824	366	95.23%

Note 1: the actual output value of the model does not include the raw materials still in production at the end of 8 hours

Note 2: the theoretical maximum value of output is based on eight CNC machines working continuously for 8 hours

4. Conclusion

By using autocorrelation and cross-correlation, the model respectively analyzes the influence of the current position and predetermined position of RGV on the size of the pressing value, and obtains the optimal system work efficiency through dynamic analysis and rolling optimization.

References

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