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Cellular Automata Simulation of RGV Dynamic Scheduling Model

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Abstract

For the RGV intelligent scheduling problem, this paper uses a heuristic search algorithm and a cellular automaton to simulate its scheduling process. For the processing of materials in one process, based on the queuing theory short service priority service criterion (SJF), the cellular automata simulation was carried out on the CNC loading and unloading situation of RGV reflected in different processing materials, with continuous operation time per shift (The heuristic priority search algorithm with T=8h) production quantity and RGV waiting time as the evaluation function yields an optimal solution scheduling scheme. For the processing of two material processes, this paper considers that the intelligent addition system has two different processes. The number and location of CNCs processing different processes will affect the production efficiency rate, which in turn affects the scheduling rules of RGV and redefines them. The cell update rule is obtained, and the optimal scheduling scheme and the CNC position arrangement of different processes are obtained. In the case of possible failure during CNC reprocessing, the CNC position of the fault is generated by the random seed of the computer during the simulation process, and the fault duration is processed. Considering that the fault occurs is a random factor, under the specific operating parameters, In these two cases, the RGV dynamic model in this case is randomly simulated by a computer, and the expected value of the maximum material for each shift of the continuous operation time and the expected number of unfinished materials after the failure occur are obtained.

Keywords

Cellular automata simulation; heuristic search algorithm; dynamic scheduling strategy; productivity; RGV waiting time; random seed.

1. Introduction

An intelligent processing system consists of eight computer numerical control machine tools (CNC), one rail-type automatic guided vehicle (RGV), one RGV linear track, one feeding conveyor belt, and one feeding conveyor belt. The workflow of the system is: After power-on, RGV is located between CNC1# and CNC2#. The CNC sends a demand signal, and the RGV receives the command. Before moving to the CNC, the loading conveyor sends the raw material to the front of the CNC for RGV loading. After the RGV completes the loading and unloading operation for a CNC, it will rotate the arm to move the clinker from one robot to the top of the cleaning tank for cleaning. After completing a task, RGV immediately determines the execution of the next job instruction. At this time, if no other

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job command is received, the RGV waits in place until the next job command. After a CNC completes the processing task of a material, it immediately sends a demand signal to the RGV. If the RGV fails to arrive at it immediately, the CNC will wait. The two process materials processing operations consider the fault situation, study the general problem, give the RGV dynamic scheduling model and the corresponding solving algorithm, get the system operating parameters, and verify the practicability of the model and the effectiveness of the algorithm.

2. Experimental process

2.1 Cellular Automata Simulation

2.1.1 cellular automaton

The cellular automaton is an idealized model of the physical system in which both space and time are discrete, and the physical parameters only take a finite set of values. It has the ability to simulate the spatio-temporal evolution process of a complex system. The cellular automaton consists of cell, cell space, neighbors, and rules. Composition [1].

A standard cellular automaton is a four-tuple composed of cell, cell state, neighborhood, and state update rules. The mathematical symbol can be expressed as: $A=(L_d, S, N, f)$.

A: Cellular automaton system; L_{d}: Cell space; d: The dimension of the cell space, which is a positive integer; S: a limited, discrete set of states of the cell; N: a collection of all cells in a neighborhood; f: Local mapping or local rules.

2.1.2 Network Model

The whole workshop is set as a d=2 two-dimensional grid system, which is divided into grids with uneven size. Each grid acts as a cell representing a material processing station or cache, and the whole system has no moving elements. Cell [3].

The two-dimensional grid $Cell_{ij}$ row represents the working state of the i-th CNCi# in the j-th second, defining the cell space as the $m \times n$ matrix, m representing the number of CNCs, and n representing the continuous operation time of each shift Ts, in this document, $n = 28800$ meshing only represents individuals. The simulation proceeds according to the set time step. The newly arrived particles (including the three cases) and the unfinished workpieces of the previous time step are used as the initial particles of the next initial stage, and the cells and particles are updated in real time according to the model evolution rule. The state, the dynamic scheduling strategy of intelligent RGV [2].

$$Cell_{ij} = \begin{cases} 0, \text{(The current ith second CNCi\# is idle)} \\ 1, \text{(The current ith second CNCi\# is busy)} \end{cases}$$

2.1.3 grid status description

In the cellular automaton, the state of a cell at a certain moment is only related to the state of the cell at the previous moment and the state of the neighboring cell at the previous moment [2], represented by the dynamics function $S_i^{n-1} = f(S_i^{(t)}, S_N^{(t)})$. The model contains two types of cells, which are divided into $Cell$ updated state cell by time, and the state cell is to be updated. Because the update cell and the cell to be updated have two working environments, the processed material is busy 1, unprocessed. The material is idle $cell$ =0. According to the scheduling rule, since the state of the cell $Cell_{i,j+1}$ to be updated at j+1 is as shown in Fig. 1, it is only related to the state of the processed material of all the updated cells $C\mathrm{ell}_{i,j}$ at time j.

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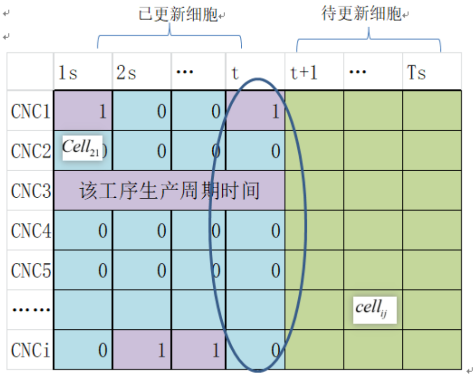

Figure 1. Cell state.

2.1.4 Evolutionary rules

The traditional cellular automaton model is often composed of a regular two-dimensional cell grid, so depending on the type of neighbor, it can be determined that there are several rules. For example, for a VonNeumann neighbor, the unit (i, j) has four neighbor units, namely: $(i, j-1),(i, j+1),(i-1, j),(i+1, j)$ these four units and the central unit itself can form many combinations, each combination may produce a rule, so you can design a variety according to the situation of the neighbors and considering the actual situation theory. Rule [4].

	$i-1, j$	
$i, j-1$	i, j	$i, j+1$
	$i+1, j$	

Figure 2. Neighbors of the cell.

For the solution process of a problem, it is essentially from the starting state, using the rules to change the state, reaching the target state, connecting the changes of the state becomes the search path, and each step of the heuristic search algorithm tries to move toward the target state. The direction is searched [5], the position of each search is evaluated, a good position is obtained, and then the search is performed from this position, so that a large number of unnecessary search paths can be omitted [6].

The standard heuristic search algorithm has an initial state I and a target state G, and some intermediate state M is also generated during the search. The occurrence function D(i) is procedural knowledge, which is an operator that produces all child nodes for a given node. In heuristic search, there are also some auxiliary strategies, such as the valuation function f(x), which estimates the value of each node, and selects the desired node to search according to the value of each node obtained [7]. The basic process of heuristic search can be expressed as $B=(I, M, G, D(i), f)$ by mathematical symbols as follows, and B represents a heuristic search system.

1.Initial state

Initial state, system operation flow: After the intelligent processing system is powered on, RGV is in the initial position between CNC1# and CNC2#, all CNCs are in idle state, that is, cell $cell_{i,0}$ at $t=0$ time is in the initial state, and the working state is 0.

2. Target status

Principle 1: Productivity is the highest, productivity is the production per unit time in the production line;

Principle 2: Machine utilization, RAT is the ratio of working time to waiting time in time T.

So define the target state below:

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For a certain scheduling scheme Q^k, let $amount(Q^k)$ be the number of materials in one production cycle of the scheme.

1. The number of clinker produced in a shift cycle: $\max \sum_{Q^K \subset S} amount_i(Q^k)$

2. RGV idle time: $\min\ \mathrm{offtime}(\mathrm{Q}^k)$

3. Occurrence function

Based on the target state, determine the occurrence function, the occurrence function: $D(i)$:

In an idle state, $cell_{ij} = 0$, $D(i) = t_{移动} + t_{上料}$; $Cell_{ij} = 1$, $D(i) = t_{下料} + t_{清洗}$.

4. Valuation function

The estimation function, based on the target state 2, minimizes the RGV wait time. According to the short job priority service (SJF) criterion of the queuing theory, that is, the workpiece with the shortest service time in the waiting queue is selected for priority processing [7], we define the transfer. The time function, taking into account the different working states of the cell, gives the following function:

$$f(x) = min(t_{移动} + t_{上料}, t_{下料} + t_{清洗})$$

2.1.5 Solution Algorithm

For a certain scheduling scheme Q^k, the target model of the task scheduling can be described as an objective function:

$$F_1 = \max \sum_{Q^K \subset S} amount_i(Q^k)$$

$$F_2 = \min \mathrm{offtime}(\mathrm{Q}^k)$$

$$\text{s.t.} \begin{cases} choice_{t+1}(i) = j \left| \begin{matrix} \min\{D_j\} \\ 1 \le j \le m \end{matrix} \right. \\ D(i) = t_{移动} + t_{上料}(cell_{ij} = 0) \\ D(i) = t_{下料} + t_{清洗}(cell_{ij} = 1) \\ \max \sum_{S} \left(cell_{i+1,j} - cell_{i,j} \right) = 1 \\ \sum_{i=1}^{m} cell_{i,j} \ge 1 \end{cases}$$

The description of the objective function and constraints is as follows:

The objective function 1 represents productivity:

The number of production materials per continuous operation time (T=8h);

The objective function 2 indicates that the RGV waiting time is the smallest;

Constraints 1, 2, and 3 indicate that RGV evolves according to the MJF rule;

Constraint 4 indicates that the RGV serves only one CNC at any one time;

Constraint 5 indicates that there is always one CNC at work at any time.

For material processing operations with only one process, the RGV scheduling process is as follows:

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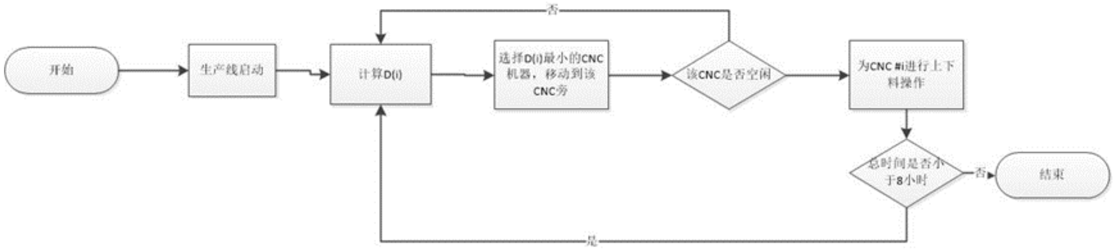

Figure 3. RGV Scheduling for a Process Material Processing Job.

Define a static two-color matrix as follows:

$$color(cell_{ij}) = \begin{cases} black(\text{第i台CNC在第j秒时处于忙碌状态}) \\ white(\text{第i台CNC在第j秒时处于空闲状态}) \end{cases}$$

The material processing operation in two processes, each CNC can only complete the processing of one of the processes, then the division of labor of the CNC has 2^8 kinds. The material processing of the two processes is still based on the cellular automaton modeling of the search algorithm. In the model of the machining operation of one process, the initialization state is unchanged, and the change of D(i) and D(i) is changed as shown in the flow chart of the following figure. The CNC of different divisions is discriminated by D(i), and the target state is determined. The same, for the target scheduling problem, it is the same as a process processing model, but choice(i) is changed, and choice(i) is changed by empowerment.

2.2 RGV dynamic scheduling model considering faults

2.2.1 Material processing operations in consideration of a faulty process

Considering that the CNC may fail during processing, the probability of failure is about 1%, and each troubleshooting time is between 10-20 minutes. After the troubleshooting, the sequence of operations is added. Taking into account the failure, the program generates a random number seed, we give the probability of the material appearing at a certain time.

2.3 Material processing operations considering the two processes of failure.

Based on the RGV scheduling model of the material processing operation of the two processes, the random probability is generated for the given probability of failure. The scheduling flow chart is as shown below, and the cellular automaton simulation is still used.

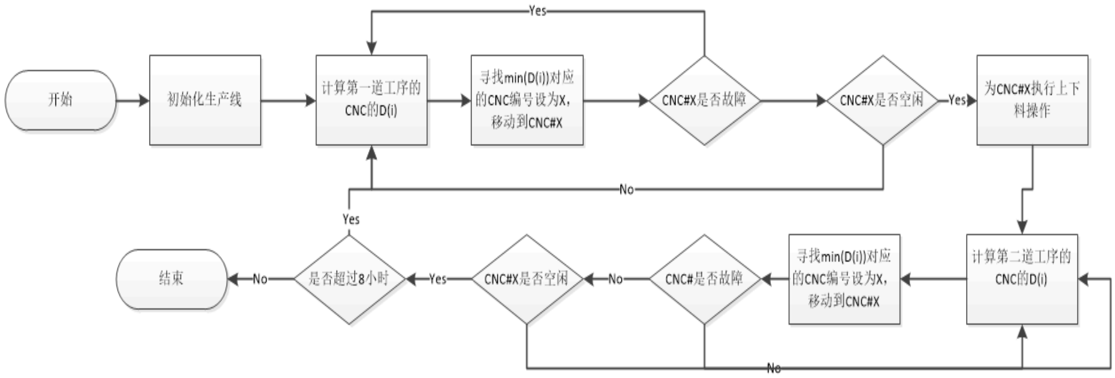

Figure 4. RGV scheduling for two process operations considering failures

Start state

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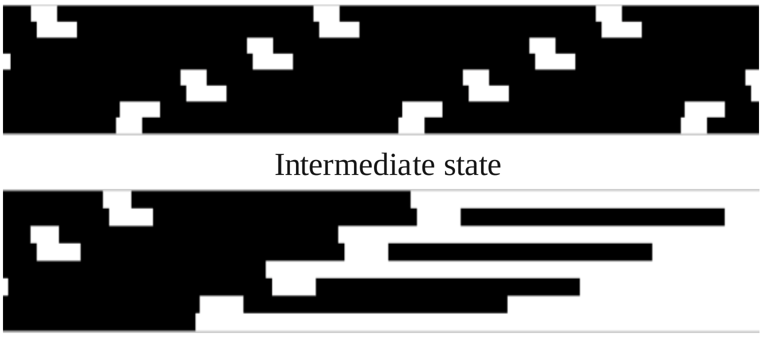

Intermediate state

End state

Figure 5. The first set of parameter cellular automaton simulations for the two processes that consider the fault.

3. Conclusion

Ordinary cellular automata are constantly changing over time, and only one state can be seen at a time. If we use the traditional cellular automaton, it is difficult to understand the whole process of CNC production. Therefore, this paper uses C++ programming to use time as the horizontal axis and CNC as the vertical axis. Then we import the matlab to generate the image and display it on the 2D plane. The entire production process can be understood globally to master the rules. The system scheduling scheme has been used to find the rules and has certain guidance for production. Using the random number seed, the failure rate and failure time are better simulated, and the result is complete. Considering the fault condition, after the failure of the CNC, the unfinished material is scrapped and becomes a defective product. This article ignores the waste of production cost caused by this factor; this paper is ideally, without considering the time of transferring the material, the direct assumption The materials are sufficient, but they generally follow the Poisson distribution with customer demand and delivery time.

References

[1] Zhang Wei, Zhang Hu, Lu Wei. Cellular genetic algorithm and its application [M]. Science Press, 2014.

[2] Chen Yong, Zhai Xingcong, Lu Jianxia. Simulation of Dynamic Flexible Scheduling of Large Parts Production Workshop Based on Cellular Automata[J]. China Mechanical Engineering, 2010, 21(21): 2603-2609.

[3] Zheng Zhong, Xu Le, Gao Xiaoqiang. Simulation Model of Workshop Crane Dispatching Based on Cellular Automata[J]. Systems Engineering - Theory & Practice, 2008(2): 137-142.

[4] XU Hong-xiang, WU Jing-hua, ZHANG Xiang-hua. Collaborative Design Task Scheduling Model Based on Cellular Automata Theory[J].Journal of Jiangsu Teachers University of Technology,2011,17(10):1-6.

[5] Gong Jianhua. Depth-first search algorithm and its improvement [J]. Modern Electronic Technology, 2007 (22): 90-92.

[6] Li Junqing. Analysis of improved strategy for heuristic search algorithm [J]. Computer CD Software and Application, 2012 (05): 36.

[7] Zhang Wei, Li Xianxian. Grid Information Query Optimization Based on Heuristic Search Algorithm[J]. Computer Engineering, 2008(19): 26-29.

[8] Zhang Jianqiu. Research on flow shop scheduling problem based on Markov-based queuing model [D]. Lanzhou: Lanzhou University of Technology, 2017.