Research on Intelligent Scheduling and Monitoring Method of Workshop Logistics System

Kai Zhou¹, Shuai Yang¹, Jingtao Zhang¹, Xiaojun Long¹ and Zhen Wang².*
¹School of Mechanical and Electronic Engineering, Shandong Agricultural University, Tai’an, China
²Logistics Management Office, Shandong Agricultural University, Tai’an, China

*Corresponding author e-mail: wangruyi9696@sdau.edu.cn

Abstract. This paper proposes a complete set of workshop scheduling and monitoring methods for the current problems of the inability to intelligently schedule logistics tasks in the workshop and the difficulty in monitoring the workshop site. First, to realize the intelligent scheduling of workshop logistics tasks, this paper proposes an artificial bee colony learning (ABC-L) algorithm based on reinforcement learning (RL), and realizes the route optimization and adjustment of the scheduling scheme through three-dimensional simulation. Secondly, to track and monitor the logistics progress of the workshop in time, this paper builds the sensor network of the workshop and establishes the virtual-real mapping model of the workshop site. Finally, to deal with emergencies in the workshop, the intelligent decision of scheduling is realized through the knowledge base of the workshop environment and behavior decision. In addition, this article combines the above-mentioned scheduling, simulation, monitoring, and intelligent decision functions to develop an integrated software platform and test it.

Keyword: Workshop scheduling; Virtual-real mapping; Intelligent decision.

1. Introduction

Intelligent workshop scheduling refers to the reasonable command, control and adjustment of effective resources in the workshop production process, so that the work to be processed can be arranged on each machine in a balanced manner, so that the completion time is shortest, and the economic efficiency is improved [1-2].

Since the workshop scheduling problem was put forward, many researchers have gradually begun to pay attention to the study of workshop scheduling problems and have achieved great research results, but there are still the following problems [3-4]: At present, most workshop logistics scheduling uses manual calculation, which has low accuracy and low efficiency; There are few studies on multi-objective workshop scheduling, and multi-objective scheduling is more in line with the actual production situation; It is difficult to make intelligent decisions about emergencies during the operation of the workshop, and most of them rely on human methods to deal with emergencies.

In response to the above problems, this paper combines artificial bee colony (ABC) algorithm with reinforcement learning (RL) [5-6], and proposes an artificial bee colony learning algorithm (ABC-L), which effectively solves the problem of intelligent scheduling of workshop logistics, and realizes...
scheduling experiment and optimization based on three-dimensional simulation; By arranging the sensor network, the virtual-real mapping model of the workshop can be obtained, and real-time monitoring of materials, equipment, production progress and on-site conditions of the workshop can be carried out; Intelligent decisions can be made on emergencies through the knowledge base, and the running path can be automatically updated through real-time scheduling. Finally, this paper develops an integrated software platform that integrates scheduling, planning, simulation, monitoring and intelligent decision functions.

2. Planning and simulation of workshop logistics

2.1. Dynamic scheduling of logistics tasks based on ABC-L algorithm

This paper combines the bee colony algorithm with the reinforcement learning algorithm, and proposes an artificial bee colony learning algorithm to optimize the scheduling of logistics distribution tasks, with the goal of the shortest completion time, and finally obtain the execution sequence and time planning of logistics tasks. Figure 1 shows the process of reinforcement learning. The agent chooses actions based on the merits of rewards [7-10]. Figure 2 shows the logistics task scheduling scheme obtained by the ABC-L algorithm, which can reasonably arrange multiple processes of different workpieces on different machines.

![Figure 1. Flow chart of reinforcement learning.](image1)

![Figure 2. Scheduling scheme for workshop logistics tasks.](image2)

2.2. Path planning and simulation of logistics tasks

After the optimal scheduling scheme is solved by the ABC-L algorithm, the starting station, target station, transfer equipment and equipment status are input, and the path parameters and node parameters are constraints, the path node search and planning are carried out, and finally a distribution path that
meets the requirements of distribution efficiency is planned, including the path sequence and node sequence, and the delivery time and equipment operating parameters are designed. Based on the results of dynamic scheduling of logistics tasks and path planning, virtual simulation of the distribution process is carried out to evaluate possible path conflicts, equipment conflicts, resource interference and other issues, and make improvements based on the simulation results to ensure the feasibility and rationality of the plan.

3. On-site monitoring and real-time control of the workshop

3.1. Establishment of sensor network

By arranging the sensor network on the workshop site, it provides the basis for realizing the workshop on-site monitoring [11]. In terms of material tracking, a QR code label is set on each material, and the material is located at different stations in the workshop by scanning the QR code. The Automatic Guided Vehicle (AGV) is positioned by means of a positioning sensor array. RFID tags are applied at intervals on the AGV path, and an RFID reader is set on each AGV. When the AGV passes a tag, the reader reads the tag information, and then locates the AGV according to the tag information. Table 1 shows the type and quantity of sensors required to arrange the sensor network, and Figure 3 shows the layout of the workshop site sensor network.

| Label | Name                  | Quantity                          | Location                        | Function                           |
|-------|-----------------------|-----------------------------------|---------------------------------|------------------------------------|
| 1     | Proximity switch      | Same as the number of locations   | Staging library and cache library | Monitoring of location status       |
| 2     | QR code               | Same as the number of materials in the workshop | Materials | Identification and tracking of material |
| 3     | Scan code gun         | 14                                | Each station and work area      | Identification and tracking of material |
| 4     | RFID reader           | 2                                 | AGV                             | AGV positioning                    |
| 5     | RFID tags             | 500                               | AGV path                        | AGV positioning                    |

Table 1. Sensor list of logistics system.

3.2. Establishment of virtual-real mapping model

Extract, identify and optimize the field multi-source sensing data collected by the sensor network to realize the unified expression of heterogeneous information. Use on-site real-time information to drive the establishment of a three-dimensional virtual model, obtain a virtual-real mapping model driven by perceptual data, and realize an enhanced display of the operating status of the workshop and the status.
of the equipment. For this model, real-time interference check, conflict alert, fast simulation, obstacle avoidance analysis, decision support and abnormal display can be realized, providing a decision-making basis for the intelligent management and control of the logistics distribution process. Figure 4 is a scheme for establishing a virtual-real mapping model of the workshop site based on the data sensed by the sensor network.

**Figure 4.** Design scheme of virtual-real mapping model.

### 3.3. Intelligent decision and real-time control based on knowledge base

The purpose of establishing the virtual-real mapping model is to realize that the system can make behavioral decisions autonomously and intelligently in the event of emergencies in the scene, reduce the negative impact caused by the emergencies, and improve the safety and accuracy of material distribution. Therefore, intelligent decision and real-time control based on knowledge base are the key to the virtual-real mapping of logistics. Through the workshop environment and logistics behavior decision knowledge base, it can provide a data basis for the intelligent decision and processing of emergencies. When there are emergencies, intelligent decisions are made on emergencies through virtual-real mapping models and knowledge bases, and workshop logistics are optimized through real-time scheduling. Figure 5 shows the process steps of intelligent decision and real-time control.

**Figure 5.** Intelligent decision and real-time control of workshop tasks.

### 4. Development and testing of software platform

To integrate functions such as dynamic scheduling and path planning of logistics tasks, virtual simulation of distribution process, establishment of virtual-real mapping model of workshop, and intelligent decision, this paper developed an integrated software platform and tested it. Figure 6 is the initialization interface of the software, in which the viewing angle mode can be set and the database connection can be monitored. By choosing different perspectives, the workshop site can be monitored well. Figure 7 shows the virtual-real mapping interface, where on-site equipment status monitoring,
workshop environment monitoring, distribution risk monitoring, logistics obstacle monitoring, etc. can be performed. The software platform can predict the possible conflicts, interferences and collisions based on the simulation of the production process, and provide the management personnel with feasible solutions.

Figure 6. Initialization interface of the software platform.

Figure 7. Virtual-real mapping interface.

5. Conclusion
To solve the problems of difficulty in rationally arranging the processing sequence of complex workshop logistics tasks and the inability to reasonably monitor the on-site workshop. First, this paper improves the bee colony algorithm, proposes the ABC-L algorithm based on reinforcement learning, and conducts dynamic scheduling and simulation of logistics tasks; Secondly, real-time monitoring of workshops and virtual-real mapping models are established by establishing a sensor network, and intelligent decision and real-time control of abnormal conditions in the workshop are carried out through the knowledge
Finally, this paper develops a software platform that realizes the integration of functions such as scheduling, planning, simulation, monitoring, intelligent decision and real-time control.

Acknowledgments
This work was financially supported by China Postdoctoral Science Foundation (2019M662410) and China Agriculture Research System of MOF and MARA (CARS-24-D-01).

References
[1] Ronghua Chen, Bo Yang, Shi Li, et al. A self-learning genetic algorithm based on reinforcement learning for flexible job-shop scheduling problem[J]. Computers & Industrial Engineering, 2020, 149 (1993): 106778.
[2] Wu Xiuli, Li Jing. Two layered approaches integrating harmony search with genetic algorithm for the integrated process planning and scheduling problem[J]. Computers & Industrial Engineering, 2021, 155 (11): 107194.
[3] Yi Tian, Lei Deming. A survey of researches on artificial bee colony for production scheduling[J]. Journal of Hebei University of Technology, 2020, 49(04): 24-32.
[4] Wang Ling, Deng Jin, Wang Shengyao. Survey on optimization algorithms for distributed shop scheduling[J]. Control and Decision, 2016, 31(01): 1-11.
[5] Zhou Kai, Wen Yongzhao, Wu Wanying, et al. Cloud Service Optimization Method Based on Dynamic Artificial Ant-Bee Colony Algorithm in Agricultural Equipment Manufacturing[J]. Mathematical Problems in Engineering, 2020, 2020 (1): 1-11.
[6] Zhang Dongyang, Ye Chunming. Reinforcement Learning Algorithm for Permutation Flow Shop Scheduling to Minimize Makespan[J]. Computer Systems & Applications, 2019, 28(12): 195-199.
[7] Xiao Pengfei, Zhang Chaoyong, Meng Leilei, et al. Non-permutation flow shop scheduling problem based on deep reinforcement learning[J]. Computer Integrated Manufacturing Systems, 2021, 27(01): 192-205.
[8] Wan Lipeng, Lan Xuguang, Zhang Hanbo, et al. A Review of Deep Reinforcement Learning Theory and Application[J]. Pattern Recognition and Artificial Intelligence, 2019, 32(01): 67-81.
[9] Luo Hao, Liu Yu. Enhanced mutual learning artificial bee colony algorithm[J]. Computer Engineering and Applications, 2016, 52(16): 23-29+45.
[10] Xu Xinli, Hao Ping, Wang Wanliang. Multi-agent dynamic scheduling method and its application to dyeing shops scheduling [J]. Computer Integrated Manufacturing Systems, 2010, 16(03): 611-620.
[11] Zhou Kai, Zhang Jingtao, Qi Xing, et al. Fault diagnosis of spraying workshop based on BP neural network [J]. Journal of Physics: Conference Series, 2021, 1952(3): 032074.