Digital twin process and simulation operation control technology for intelligent manufacturing unit

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Abstract. In the manufacturing process, the intelligent manufacturing unit will produce unexpected situations with different forms and a large amount of data. How to control the intelligent manufacturing unit more intuitively and effectively control the operation and control of the trolley is an urgent problem to be solved. This paper proposes a digital twin process and simulation operation control technology for intelligent manufacturing units, including virtual workshop and actual workshop real-time mapping technology and digital twin-based simulation control technology. Through these two technical means, intelligent manufacturing unit realized visual real-time management and control. In the end, the author designed an intelligent manufacturing unit management system to successfully verify the effectiveness of the above technology.

1. Introduction
At present, there have been many studies about the application of digital twin technology domestic and abroad. The concept of digital twin was first proposed by Professor Grieves in the product lifecycle management course at the University of Michigan in 2003 and was defined as a three-dimensional model, including physical products, virtual products, and connections between them[1]. Domestic Cunbo Zhuang, Jianhua Liu, etc.[2] proposed the concept of digital twin technology, and pointed out that digital twins are technologies, processes and methods, and digital twins are objects, models and data. It is pointed out that digital twinning technology not only uses human existing theory and knowledge to build virtual models, but also uses virtual model simulation technology to explore and predict the unknown world, and constantly stimulates human innovative thinking, which provides new ideas and tools for the current manufacturing innovation. Fei Tao [3] proposed the implementation mode of the digital twin workshop, and defined its system composition, operation mechanism, characteristics and key technologies, which provided a theoretical and method reference for the realization of CPS in the manufacturing workshop.

Digital twin is a virtual model that creates physical entities in a digital way. It simulates the behavior of physical entities in real-world environments by means of data, and adds or expands physical entities through means of virtual and real interaction feedback, data fusion analysis, and decision iterative optimization, add or extend new capabilities for physical entities. As a technology that makes full use of models, data, intelligence and integrated multidisciplinary, digital twin provides a more real-time, efficient and intelligent service for the whole life cycle of products and the bridge and the link between
the physical world and the information world[3-5]. The first task of implementing a digital twin application is to create a digital twin model of the object. At present, the digital twin model mostly uses the three-dimensional model originally defined by Professor Grieves, namely physical entities, virtual entities and the connection between them [6]. However, most of the digital twin in practical applications mainly focus on three-dimensional visualization of the workshop and manufacturing information. For example, many of them have done three-dimensional visualization of the workshop, think that this is digital, but it is not. Digital twin emphasizes the synchronization between virtual and real, the operation of the actual workshop is consistent with the operation of the virtual workshop, and the virtual workshop can receive information from the actual workshop and make adjustments. Similarly, the actual workshop can make changes which are based on the commands issued by the virtual workshop.

This paper will focus on the problem of visual control of intelligent manufacturing unit of an enterprise, combined with the development of management software, focusing on the digital twin process and simulation operation control technology of intelligent manufacturing unit to realize the high-efficiency control of the intelligent manufacturing unit.

2. Digital twin process and simulation operation control technology framework
Through the SolidWorks software, the machine equipment, the staff and the AGV and other equipment facilities in the intelligent manufacturing unit are scaled and 3D modeled, and then saved into the step format and imported into the 3ds MAX software, and then exported after the software is rendered. Finally, it is imported into Unity software to build a virtual intelligent manufacturing unit. Finally, it is embedded into the control system of WinForm, and the data from the intelligent manufacturing unit is accepted through the control system, and feedback to the intelligent manufacturing unit in real time. The digital twin process and simulation operation control technology for intelligent manufacturing units mainly study how to realize the virtual and real synchronization between the virtual workshop and the actual workshop, and realize the data transmission and feedback. Therefore, the part of the virtual intelligent manufacturing unit is not excessively described. This paper will briefly explain the framework of digital twin process and simulation operation control technology in conjunction with Figure 1.

Figure 1. Digital Twin Process and Simulation Operation Control Technology Framework.
The technical framework of the digital twinning process and simulation run control technology for the intelligent manufacturing unit shown in Figure 1 is mainly composed of two technologies: virtual workshop and actual workshop real-time mapping technology and digital driving simulation control technology based on digital twin. The main applications are as follows:

1. Virtual workshop and actual workshop real-time mapping technology. Real-time mapping and virtual reality synchronization are two basic characteristics of digital twin. The core of the data is the data-driven model, which is to obtain real-time transformed data from the actual workshop, and transmit it to the virtual workshop in real time through the data transfer station, so as to realize real-time virtual workshop and actual workshop mapping technology.

2. Digital driving simulation control technology based on digital twin. The intelligent manufacturing unit contains the AGV. The AGV in the actual workshop runs synchronously with the 3D model of the AGV in the virtual workshop, but this is not enough. The fundamental purpose of digital twin is decision analysis, so it is extremely critical for the simulation operation control of the AGV. The material transported by the AGV can be simulated in the virtual workshop in advance, and the optimal solution is selected, thereby improving the working efficiency of the AGV and further improving the production efficiency of the intelligent manufacturing unit. In view of this, this paper proposes digital driving simulation control technology based on digital twin.

3. Key technology
The foregoing has briefly introduced the role of two key technologies in the overall framework of digital twin process and simulation operation control technology for intelligent manufacturing unit. The specific implementation principles of these two key technologies are described in detail below.

3.1. Virtual workshop and actual workshop real-time mapping technology
In order to realize the real-time synchronization between the virtual workshop and the actual workshop, it is convenient for the manager to view the real-time information of the workshop and the management workshop. This paper proposes the real-time mapping technology between the virtual workshop and the actual workshop. In addition to the three-dimensional modeling of all objects in the actual workshop, all the information in the workshop needs to be summarized and organized to clarify which data needs to be transmitted to the virtual workshop to implement the data-driven model. The specific implementation process of the virtual workshop and the actual workshop real-time mapping technology is shown in Figure 2.

![Figure 2](image_url)
In order to realize the synchronous operation of the virtual workshop and the actual workshop, the 3D models in the virtual workshop need to be driven according to the data of the real-time transformation of the actual workshop. According to the data source shown in Figure 2, there are two parts, namely the data of the workshop service system and the data in the twin database. The data in the twin database is mainly through the Internet of Things and UWB deployed in the actual workshop. The Internet of Things and UWB can monitor the movements in the actual workshop in real-time, such as the location changes of people, AGV, materials, etc., and can send three-dimensional coordinates to the twin database in real time, and then transfer the data to the virtual workshop, the corresponding three-dimensional models in the virtual workshop synchronously change locations. The data in the workshop service system is mainly the order task, tooling management, material management and other data. Compared with the delivery and completion of the order task, the data reaches the actual workshop and also reaches the virtual workshop, thus realizing the virtual workshop real-time mapping with the actual shop floor.

Various types of information are generated all the time in the actual workshop. In order to realize the real-time mapping between the virtual workshop and the actual workshop, and to realize the data-driven model, it is necessary to summarize and sort all kinds of information in the actual workshop. For example, the information of the workpiece, first of all, to determine the real-time position of the workpiece, that is to obtain the three-dimensional coordinate information of the workpiece from the twin database, in order to drive the change of the workpiece position in the virtual workshop, as well as the workpiece in and out of the shop signal, the current workpiece’s position, the current process of the workpiece, and all the operations of the workpiece are shown in Table 1. In addition to the workpiece information, there are information such as machine tools, people, AGV, etc.

### Table 1. Workpiece information table.

| Data Name | Data Form                  | Return Value                                      | Change Node     | Function |
|-----------|----------------------------|--------------------------------------------------|-----------------|----------|
| Workpiece | 3D coordinates             | Workpiece position in real time                   | Position change | Drive    |
| Workpiece | 0/1                        | Workpiece in and out of the shop signal           | Whether the workpiece is in the workshop | Drive    |
| Workpiece | Text                       | Workpiece current station                         | Station change  | Show     |
| Workpiece | Text                       | Current process of the workpiece                  | Process change  | Show     |
| Workpiece | Text or flow chart          | All processes of the workpiece                    | No              | Show     |

### 3.2. Digital driving simulation control technology based on digital twin

AGV is an automated transportation device that can perform specified transportation tasks in a given path and scene information layout, which is of great significance for improving the production efficiency of intelligent manufacturing units and reducing production costs. Therefore, this paper proposes a digital driving simulation control technology based on digital twin. First, it is necessary to build a virtual workshop in Unity3D that is consistent with the actual shop floor, and bind the state machine and data drive conditions to the AGV model. When the condition is met, the AGV will run on the specified path. Secondly, it is also necessary to use the AGV path planning algorithm to formulate the AGV trajectory and obtain the optimal solution of the AGV trajectory. The main process is to first judge whether the task queue is empty. If it is not empty, the first task needs to be selected according to the task priority. Perform path time calculation on the task to determine whether there is overlap in the time window. If there is no overlap, the node registers the AGV and the time window. If they overlap,
the time window is advanced or pushed back to find the idle time. The process is repeated until the task team is empty. Finally, the simulation runs in the virtual workshop according to the results, and the node and time information are output after the end. The realization process of the simulation control technology based on digital twin is shown in Figure 3.

![Diagram](image)

**Figure 3.** Implementation process of digital driving simulation control technology based on digital twin.

4. **Experimental verification**

This paper studies the digital twin process and simulation operation control technology for intelligent manufacturing unit. Based on this, combined with the development of intelligent manufacturing unit management system, a corresponding system is designed, and the real-time mapping technology between virtual workshop and actual workshop is solved by this system. Based on the application of digital twin simulation control technology in actual production, the virtual workshop is built to solve the real-time visual control and AGV simulation operation control of the intelligent manufacturing unit control system for the actual workshop.

In this system, the data in the actual workshop, such as AGV, staffs and workpiece changes, can be transmitted to the system through the twin database, and finally to the virtual workshop, to achieve a series of changes in the model flow, location update, etc., thereby to achieve real-time mapping purposes. As shown in Fig. 4 and Fig. 5, it is also possible to control the path simulation of the AGV, calculate the optimal path of the AGV operation and simulate in the virtual workshop to realize the simulation operation control of the AGV based on digital twin.
5. Conclusion
This paper studies the digital twin process and simulation operation control technology for intelligent manufacturing unit. Based on this, combined with the development of intelligent manufacturing unit control system, a corresponding system is designed, and these two technical means are applied to
establish the virtual workshop and the corresponding twin database for the purpose of solving the real-time mapping between the actual workshop and the virtual workshop and the simulation control operation based on the digital twin-based vehicle path, which improve the digital level of the intelligent manufacturing unit and the operating efficiency of the AGV.

6. References

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