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The Intelligent Workshop of Construction Machinery Incorporating Internet of Things Technology

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Abstract: With the continuous penetration of the Internet of Things concept into the manufacturing industry, this adoption of information-aware technology will give a strong impetus to the development of the implementation system of the intelligent workshop of construction machinery towards informatization, greening and globalization. The purpose of this paper is to study the intelligent workshop of construction machinery based on the Internet of Things technology. Firstly, the actual needs of intelligent workshop to build IOT are analysed; then, combined with these needs, the general framework of workshop IOT construction is given, and how to carry out data collection is studied and the data model is proposed; finally, the real-time database is studied and the design of the core part is introduced. Using RFID technology to achieve intelligent sensing and monitoring of material information, the experimental results show that applying IoT technology to the intelligent workshop can achieve more efficient workshop material management.

1. Introduction

Construction machinery plays an important role in the construction of China's national economy. The country's demand for infrastructure construction has greatly promoted the development of construction machinery [1]. With the deepening of global market economic integration, construction machinery is also facing increasingly fierce competition. Enterprises must continuously enhance their capabilities in all aspects [2]. Take a place in this increasingly tough global market economy. The development of IoT technology has strategic significance and technical value for the development of smart workshops [3].

Today, many manufacturing systems have information technology (IT) business solutions that embed Internet of Things (IoT) capabilities [4]. In response to the shortcomings of traditional shop floor information that is premature, inaccurate, ineffective and opaque, research has focused on real-time placement and monitoring of shop floor production processes. Several researchers have analysed the installation requirements and application architecture of the smart shop floor. Based on detection technology, an application solution is proposed for the construction of a smart shop. An improved Bayesian algorithm based on the Nearest Neighbour K algorithm has been designed, resulting in an increase in the efficiency of the workshop work [5]. Digitisation is fundamentally changing the face of manufacturing in the world. A system design and architecture for a remote product monitoring system on a conventional lathe has also been implemented. In addition, key technologies such as the Industrial Internet of Things, data analytics and smart sensors have been discussed and analysed. Finally, machine utilisation is primarily monitored as overall equipment efficiency, which is a measure of productivity, availability and quality. Whereas productivity is the total number of jobs produced, availability is the uptime and quality is the amount of scrap [6]. Therefore, it is of practical significance to study the intelligent workshop of construction machinery incorporating IOT technology.

Taking a construction machinery enterprise as the research object, this paper summarises the main data requirements in the information and physical system of the intelligent workshop of the construction machinery enterprise, and on the premise of solving these problems, the intelligent workshop information and physical system is established by using radio frequency identification technology, and the core part is planned and designed in detail, meanwhile, the IOT technology is applied to monitor the materials in the warehouse.

2. Research on Intelligent Workshop of Construction Machinery Integrating IoT Technology

2.1. Data Demand Analysis

Construction machinery enterprises have an urgent demand for intelligent workshop information physical system to achieve comprehensive monitoring and management of the manufacturing process, so as to improve the management level and production efficiency of the whole workshop and enhance the core competitiveness of enterprises [7]. The schematic diagram of the information requirements of the intelligent workshop information-physical system is shown in Figure 1. Based on the above analysis, the realization of manufacturing workshop informationization has the following needs:

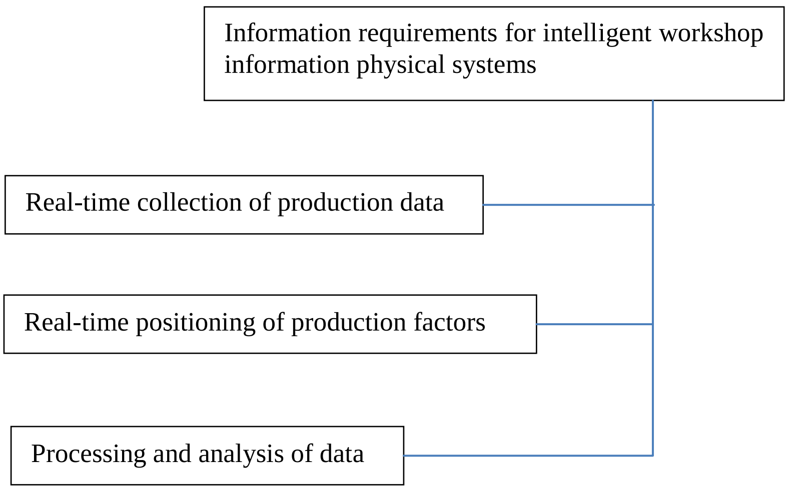

Figure 1. Information requirements diagram for information physical systems

(1) Real-time collection of production data

The traditional backward data collection method in the manufacturing process leads to inaccurate and untimely information collection and lagging information feedback, causing bottlenecks in information interaction, resulting in poor control of the manufacturing process by enterprises and inability to make timely responses to unexpected situations, ultimately leading to lower production efficiency and longer production cycles [8-9]. Therefore, through the application of information physical system in the intelligent workshop, it can provide accurate and reliable data support for workshop management through the comprehensive collection of workshop production elements data [10]. There are many types of data involved in this process, which can be divided into field data and equipment data according to their relevance to production. In addition to the positioning of the links, the field data mainly includes information on the personnel and workpieces involved, the workshop environment such as temperature and humidity, light and noise conditions [11-12].

(2) Real-time location of production elements

The discrete manufacturing process has many frequently moving production objects, such as personnel, workpieces, logistics vehicles, etc., whose locations are difficult to track and determine. For important parts or tools, finding them is often time-consuming and often results in economic losses due to loss [13-14]. The location tracking of work-in-progress can provide real-time information on the processing status of the station where it is currently located and the operation of the work-in-progress in the whole workshop; the location tracking of distribution trolleys and so on can grasp their current location in real time, realise path planning, track tracking and so on to ensure the punctuality and accuracy of distribution [15].

(3) Processing and analysis of data

The amount of data collected in the workshop production process is huge, which contains a large amount of useless information. Therefore, the raw data must be analysed and processed to eliminate redundancy and improve the information granularity of the data. So that the data can truly reflect the workshop production status, and provide the workshop management personnel in a visual way in a timely manner, so that the management personnel can easily grasp the production status of workpieces, equipment and workers, make scientific judgments and reasonable decisions on the progress of the whole workshop, optimize the workshop production scheduling, reasonably allocate manufacturing resources and improve production efficiency [16-17].

2.2. Radio Frequency Identification Technology

Radio frequency identification technology, referred to as RFID, is widely used in various fields such as transportation and storage management. According to the different data collection technologies, automatic identification technology can be roughly divided into barcode identification (one-dimensional barcode, two-dimensional code), magnetic card identification, IC card identification and radio frequency identification [18]. A comparison of their performance is shown in Table 1.

In summary, compared with other recognition technologies, RFID recognition has the following advantages.

(1) RFID electronic tag capacity is large;

(2) recognition speed is fast, can read and write electronic label information;

(3)Non-contact information automatic recognition;

(4) high data security, label life is long.

Table 1. Comparison of automatic identification technologies

One-dimensional code	QR Code	Magnetic cards	Card	RFID
Identification technology	Light recognition	Optical recognition	Electrical identification	Wireless identification
Amount of information	small	Larger	Large	Large
Readability	read only	Read only	Read/Write	Readable
Speed of reading	fast	slow	slow	Very fast
Reading distance	Near	Near	Contact	far
Service life	short	indeterminate	very long	long

3. Investigation and Research on Intelligent Workshop of Construction Machinery Incorporating IOT Technology

3.1. Construction Machinery Enterprise

In this paper, a construction machinery enterprise manufacturing plant is taken as an example to plan, design and implement an assembly production logistics execution system. The manufacturing plant has a construction area of 100,000 square metres and an effective indoor area of 85,000 square metres. It belongs to the concrete pumping manufacturing industry in the field of machinery manufacturing. The whole factory includes four parts: assembly area, material storage area, structural parts area and product display area.

3.2. RFID-based Material Identification

RFID electronic tags are mainly used for recording and storing material information and assembly information in the assembly process. By segmenting the electronic tag for coding, the distinction between static material information and dynamic material information can be realized. The working temperature range of the reader and writer is between -10℃ and 55℃. As no special waterproof and dustproof treatment is made, the reader and writer and power supply need to be installed in a protective box with waterproof, dustproof and heat insulation functions. The antenna line needs to satisfy the antenna beam communication range can cover the reliable and read the electronic label.

Will read-write install in: (1) the turnover warehouse export registration place; (2) the assembly line side of each work station; (3) the finished product warehouse entrance registration place.

Under the flexible production mode of multiple varieties, medium and small quantities, for small materials, install an electronic label on each material box box; for large materials, install an electronic label on each component; for finished products, install an electronic label on each packing box.

4. Analysis and Research on Intelligent Workshop of Construction Machinery Incorporating IOT Technology

4.1. Core Part Design

In the framework of the real-time database system, the management storage layer is the core part, which includes two modules, the real-time database and the historical database, as shown in Figure

2.

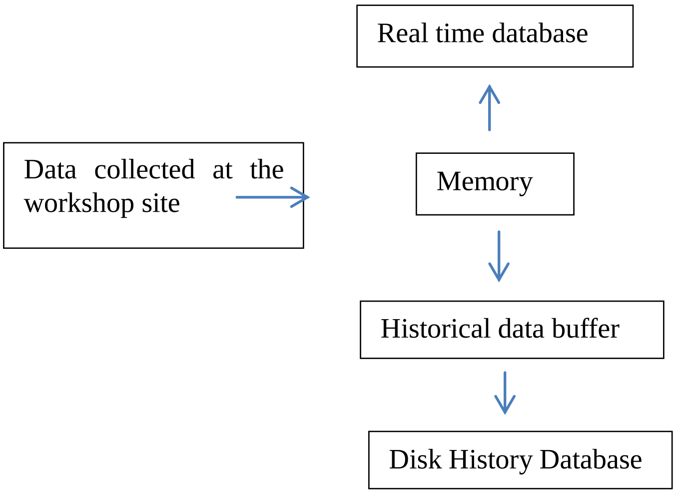

Figure 2. Core structure of real-time database system

The real-time database is used to store immediate data for the production floor intelligent monitoring system for real-time monitoring of manufacturing elements, data-driven equipment models, etc. In order to ensure that the data is realistic, the real-time database is memory resident and always stores the most up-to-date field data. The real-time database always has only the latest information for a particular piece of equipment, and the real-time data train collected at regular intervals dynamically replaces the existing data in the real-time database. In this way, the production plant intelligent monitoring system is able to obtain real-time data from the production plant site, ensuring the consistency of the system with the site. The principle is as follows:

Let the data object in the real-time database be D. At this time, the collected data is Dt, then there are:

$$D = D_t \tag{1}$$

The next data collected is Dt+T, then we have :

$$D = D_{t+T}\,(\text{T is the acquisition period}) \tag{2}$$

Dt is then replaced.

In order to avoid frequent disk writes, a history data buffer is provided in memory. The historical data cache stores historical data for a certain period of time (e.g. the same day, the same month) and then writes to the disk history database at once. This makes it easier for the production floor intelligent monitoring system to forecast trends, build early warning models, analyse data, etc., but also ensures that the data is kept for a long time. The principle is as follows:

Let Di denote a data item identified by i at a measurement point, and the data at moment t is Dit, then the data set in the history cache is :

$$R = \{D_t^i, D_{t+T}^i, D_{t+2T}^i \ldots D_{t+jT}^i\}\,(\text{j is an integer}) \tag{3}$$

Let the compression period of the history buffer be T', if :

$$\left|jT - T'\right| \leq \varepsilon(\varepsilon \to 0) \tag{4}$$

is established, the data in the history data cache is compressed and written to the disk history database.

There are usually two types of data compression: lossless and lossy. To ensure the integrity of the data, the "change-as-you-save" method has been chosen as a form of lossless compression. This means that if two adjacent pieces of data are compared, the one with the next highest timescale is discarded if they are the same; if they are different, they are both retained. And so on, to achieve the compression of data.

4.2. Warehouse Material Monitoring

Depot material management platform data is shown in Figure 3. Real-time information is collected when the material is sorted into groups of trays, and the completion of the sorting groups of trays is displayed visually, and the progress of the workstation 1 group of trays is shown in Table 2. An alarm system is also in place during the picking process to alert the appropriate person when a problem occurs, improving the efficiency of the picking process.

Table 2. Panel assembly progress of station 1

Material name	Serial number	Number of first floor	Number of second floor	Number of three floors	Completion rate (%)
Screw	1	5	12	7	30
Flat Key	2	6	10	6	35
Gears	3	6	6	5	47
Bearings	4	8	2	8	40
Valve body	5	2	7	11	57
Flanges	6	6	10	14	31

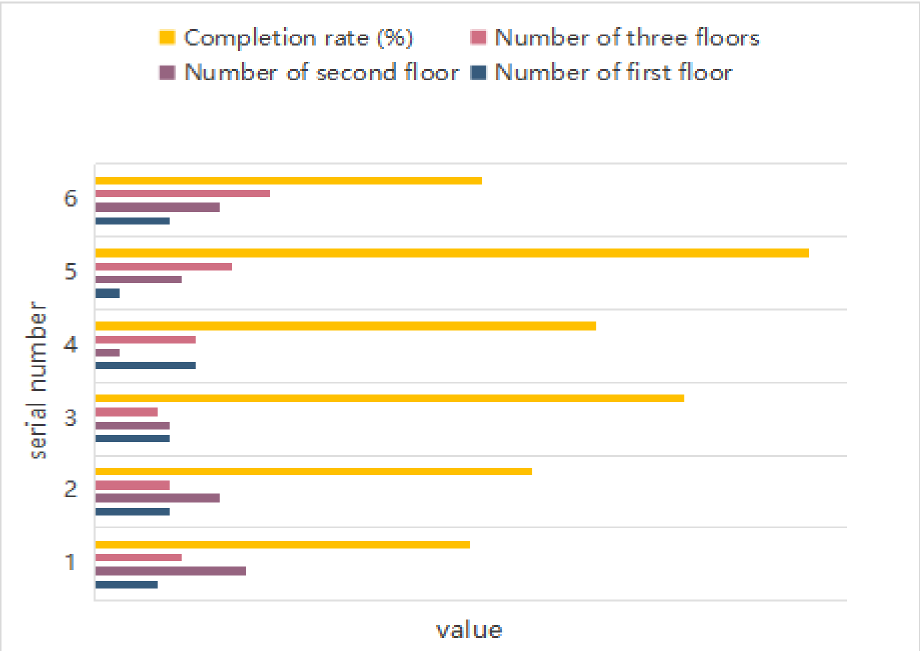

Figure 3. Warehouse Material Management Platform

Material trolley positioning management can real-time tracking material trolley in the factory location information, when the vehicle failure event, the management personnel can be reasonable vehicle management, at the same time vehicle information and vehicle distribution of material information is real-time binding, click on the electronic map of the material trolley can show the trolley current distribution situation, for the manager scheduling optimization to improve reliable information as a reference.

5.Conclusion

In the field of construction machinery, the integration of IoT technology can realize the transparent and lean management of the production logistics process of construction machinery. This paper researches a kind of workshop intelligence based on IoT, but the practical application of IoT technology in workshop material distribution is still in the initial exploration stage and has not formed a mature application effect, and there is less research literature in related aspects. Due to the limited research time and capacity, there are still many shortcomings in the research, which can be further studied in the future, for example: this paper senses the workshop material information in real time through RFID technology, however, in the process of using RFID equipment, the research has not been repeatedly tested on the installation of RFID electronic tags and antennas to find the optimal read-write efficiency.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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