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Research on Real Time Data Monitoring Method for Intelligent Factory Equipment Based on Ethernet Communication

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Abstract. This article focuses on the production and processing of sleeve parts, using Ethernet as a data transmission medium to complete data collection and monitoring of typical intelligent factory processing workshops. Firstly, the layout design of the intelligent factory equipment layer, communication layer, and system application layer was completed. Then, unified management of standard and non-standard protocols was implemented for communication between different devices. Then, based on the sensors and sensor data used in each production process, a data collection scheme was designed, and finally, the data collection system was designed, Real time monitoring of data between various devices in the system can guide enterprise production.

Keywords: industrial Ethernet, intelligent plant, data acquisition, communication protocol

1 Introduction

Intelligent manufacturing and intelligent factories are both the core technologies of the new round of industrial revolution and the main focus of "Made in China 2025", and have received increasingly extensive and far-reaching research in recent years. Intelligent factories are the foundation for real-time collection and management of workshop on-site data, as well as providing data for the system described in this article. Meanwhile, smart factories are also a typical application of digitalization, automation, and Internet of Things (IoT) technology in manufacturing workshops. They highly integrate flexible manufacturing technology with process design systems, intelligent recognition technology, production organization systems, and other management systems to form an integrated manufacturing system with comprehensive information flow and automation properties.

During the processing of sleeve parts, due to the low level of automation in the production lines of most small and medium-sized manufacturing enterprises, the production environment is harsh, and the labor intensity of workers is high, resulting in the inability to ensure the accuracy of continuous operation parts. Moreover, with the continuous increase in labor costs, the development of the mechanical processing industry is gradually moving towards automation and flexibility.

Therefore, this article focuses on the processing workshop of sleeve parts and constructs a data collection and monitoring method between equipment based on Ethernet data transmission to improve the production efficiency of the workshop. The work content of this article is as follows:

1) Based on the processing characteristics of sleeve parts, a hierarchical structure of the intelligent factory system was designed, which consists of equipment layer, communication layer, and system application layer from bottom to top, and the detailed design between each layer was elaborated;

2) Manage communication protocols between various devices to facilitate data collection and centralization;

3) A data collection and monitoring system has been designed, which can achieve real-time data collection and monitoring.

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Chapter 2 mainly focuses on relevant research results, which have reference and reference significance; Chapter 3 mainly addresses the issues of hierarchical arrangement, communication between devices, and communication protocols in Ethernet links. Chapter 4 completed the distribution of data points in each stage. Chapter 5 mainly focuses on the design of data acquisition and monitoring systems. Chapter 6 is the conclusion section.

2 Related Work

Gongyan Yang et al. [1] designed and developed an MES system with parts information module, ANDON information module, equipment maintenance module, and working hour query module to address the problems existing in discrete manufacturing enterprises. This improved production efficiency and equipment utilization, enabling enterprises to discover and solve problems in a timely manner, and realizing the informatization of workshop management. Yunhua Qiao [2] proposed a batch task control model that includes modules such as planning management, material management, and workshop production by analyzing the difficulties of introducing MES systems into the large-scale electrical installation industry. The MES system was introduced and ultimately developed using technologies such as MVC and JSP Spring, achieving rapid completion of batch tasks and coordination between procurement and material distribution plans. Zujun Zhang et al. [3] designed an MES system that includes real-time monitoring, production planning, warehouse management and other functional modules. The system was developed using web front-end and back-end separation development mode, Angular JS code, SSH framework, Websocket transmission protocol, OPC middleware and other technologies, achieving real-time monitoring of on-site equipment, production planning management and control, and material classification and storage management. Ping Zhang proposed a new power distribution monitoring scheme based on real-time Ethernet, which adopts distributed layout, integrated management design, and uses real-time Ethernet as the control network to achieve centralized monitoring and management of power distribution loads, solving the problems of synchronization of underlying power distribution data and real-time transmission of control instructions [4]. Fei Wang, in response to the current problems of low efficiency in manual management equipment and poor applicability of monitoring software to multiple types of equipment in industrial manufacturing, has built a real-time data acquisition automation testing system based on OPC (OLE for process control) and FOCAS (FANUC Open CNC API Specifications) specifications, focusing on the control systems of processing equipment and CNC equipment, and achieved real-time monitoring of cloud data [5].

3 Integrated System Design for Intelligent Factory

Based on the processing characteristics of sleeve parts, the hierarchical structure of the designed intelligent factory system is divided from bottom to top into equipment layer, communication layer, and system application layer, as shown in Fig. 1.

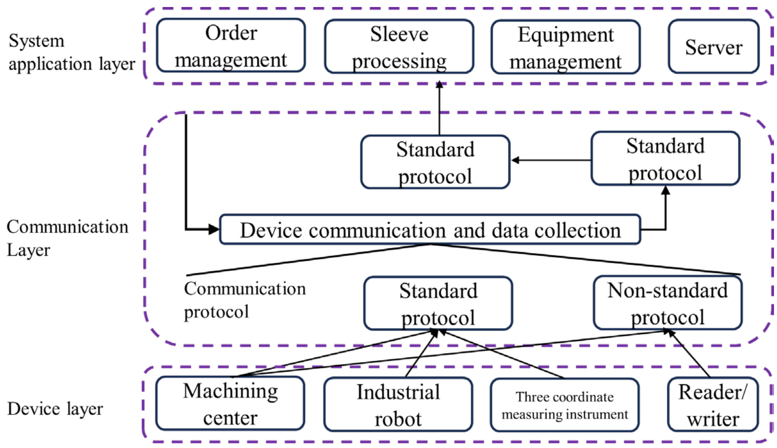

Fig. 1. System hierarchy

3.1 Printing Area

The equipment layer mainly consists of various machining centers, industrial robots, coordinate measuring instruments, and RFID readers in the workshop. The production efficiency and processing quality of machining centers directly determine the efficiency of workshop production and the processing quality of sleeve parts. Therefore, real-time monitoring of machining centers and coordinate measuring instruments is a key link. The main function of industrial robots is material handling, and coordinate measuring instruments are used to measure the machining accuracy of parts. RFID readers and writers are important auxiliary means to record information, improve machining efficiency and workshop management. Industrial Ethernet is the foundation for communication between various devices and levels. The communication layer mainly serves as the communication and data acquisition system for devices running on DNC servers, processing, storing, and transmitting data from workshop production equipment and upper level system applications. The equipment communication and data acquisition system establishes communication with various equipment in the workshop and obtains production data through various Ethernet based communication protocols such as OPC UA, FOCAS, Jingdiao, SOCKET, etc. The production data is preprocessed and stored in the equipment database; Establish a communication interface for data exchange with the upper layer applications of the intelligent factory system, so that the upper layer applications of the intelligent factory system can obtain device data through the communication interface; Obtain NC code files from the upper level CNC center, process parameters from the machining process optimization module, and scheduling production plans from the production planning and scheduling module through communication interfaces, and issue NC code files, process parameters, and production instructions to designated equipment at preset time points to control workshop equipment to produce according to the plan. The communication layer plays an extremely important role in the MES system, serving as a bridge between system applications and workshop equipment. The integrity of its functions and the stability of its operation directly affect the effective operation of the factory system.

3.2 Communication Protocol Management

Due to the different types and manufacturers of equipment, the communication protocols used are usually different. Therefore, in order to achieve communication and data collection between computers and all equipment in the workshop, it is necessary to establish a complete communication protocol library and manage multiple communication protocols. The communication protocols stored in the communication protocol library are divided into two types: standard communication protocols and non-standard communication protocols [6].

1) Standard communication protocol

The entire process of establishing communication between the computer and the machining center is as follows: first, the computer connects to the CNC system with a specified IP address and namespace address through an authenticated username and password. Then, a session is established, which is a data channel between the client and the server. Then, subscription is added. When the client needs to obtain data on events monitored by the server, the client sends a request to the server, All the data of the entire set of monitoring events in the subscription is packaged together and published as notifications to the client, thereby achieving data exchange and completing communication. The communication structure is shown in Fig. 2.

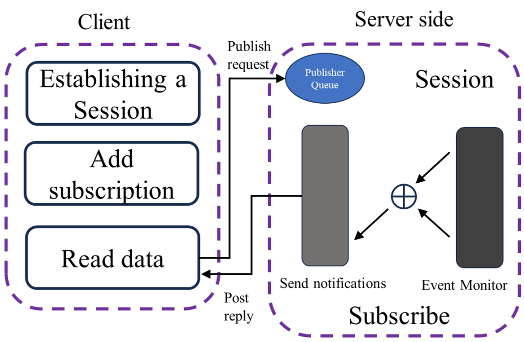

Fig. 2. Communication between client and server

2) Non-standard protocol communication

Jingdiao Communication Protocol is a protocol specifically used for communication between computers and Jingdiao 50 series CNC system machine tools. The Jingdiao communication protocol is similar to the FOCAS protocol and is also implemented based on the TCP/IP protocol. Therefore, it is necessary to set up the computer and CNC machine tool on the same network segment, write communication programs based on the OCX control developed by Jingdiao for communication, call the ConnectJDMach() function to establish communication with the CNC machine tool, and obtain data from the CNC machine tool in the same way as the FOCAS protocol, with only differences in the functions called.

4 Real Time Data Collection Scheme

The hardware part of the system can be mainly divided into three parts, namely the design of the teaching experiment platform, the design of the PLC control platform, and the design of the hardware data acquisition and storage scheme. The role of the teaching experiment platform in the architecture is to set the data types and collection requirements proposed by the enterprise in the simulation workstation of the teaching experiment platform, and design collection plans for these types of production data to provide the enterprise with digitalization of old-fashioned workshops. After selecting sensors for each data type, the PLC control platform is mainly used to collect data measured by sensors to achieve digitalization of production data [7]. The comparison table for workstation sensors is shown in Table 1.

Table 1. List of workstation sensor information

Position	Data	Sensor type	Information type
Station 1	Station 1 start time	Photoelectric switch	Digital signal
	Main spindle working information	Laser as an encoder	Analog signal
	Motor body temperature	Thermocouple	Analog signal
	Station 1 End Time	Photoelectric switch	Digital signal
Station 1	Station 2 start time	Photoelectric switch	Digital signal
	RFID information	THS401 Reader/writer	RF signal
	Station 2 End Time	Photoelectric switch	digital signal

The entire data collection scheme starts with various sensors collecting production data from the production line, all of which are programmed and collected through PLC modules. Then, the peer protocols are unified into TCP/IP protocols through Ethernet modules, and the Ethernet modules are connected to Ethernet switches through Ethernet cables. Finally, the switches are connected to computer terminals in the form of Ethernet cables. According to the above figure, the following representative data collection schemes are explained in detail, as shown in Fig. 3.

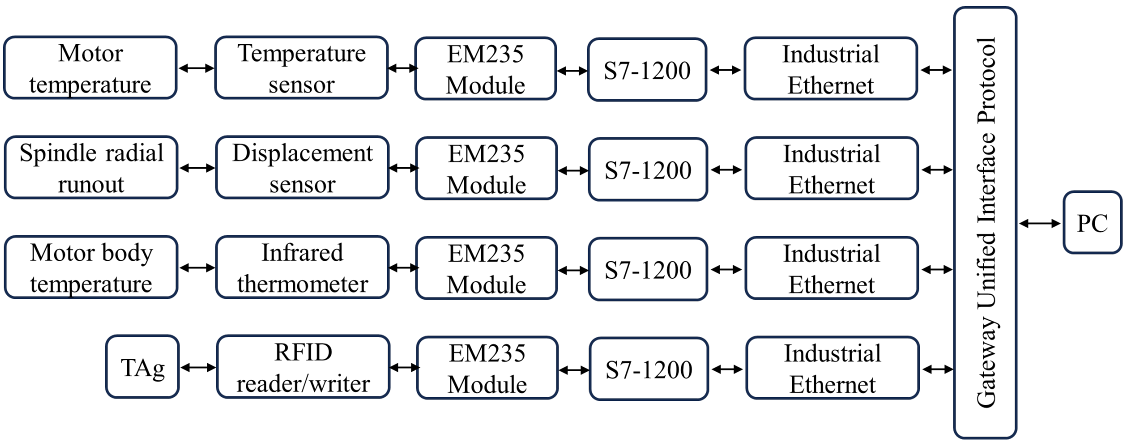

Fig. 3. Data collection plan

Please provide a detailed explanation of the following representative data collection schemes based on the above diagram. Data acquisition of radial runout of machine tool spindle: The laser displacement sensor transmits the radial runout signal of the simulated workstation motor spindle to the analog input port (AI port) of the EM235 module. An analog processing program is written on the computer terminal to enable the EM235 module to process the analog current information from the laser displacement sensor as a digital quantity and store it in the PLC register, The same principle applies to the collection of various software or information management related systems within the upper computer. The pseudocode of the program is as follows:

The pseudocode 1.

```
Start:
    Setup:
        Analog input maximum value:32000
        Analog input minimum value:6200
        Analog output maximum value:5
        Analog output minimum value:-5
  Output:
  Map (Analog input minimum value, Analog input maximum value) to
          (Analog output minimum value, Analog output maximum value)
End
```

RFID information/material information data collection: As there are four RFID readers/card readers on this platform, they cannot use traditional analog and digital data collection methods for data collection and must use the industrial protocol MODBUS protocol. However, this platform chooses to use the RTU mode in the MODBUS protocol for data collection. After initialization, the PLC will be started as the main station, and close contact M0.0 and trigger close M0.1 by network 2 position. The ultimate implementation is to activate the read and write function to perform read and write operations on RFID reader 1. The pseudocode for the operation process is as follows:

The pseudocode 2.

```
Start:
    Setup (Main station read and write instructions):
        First: Trigger Along Instruction

        Slave: Set the slave station number to 2
        RW: Read Mode
        Addr: Slave data storage address 40009
         Count: The number of communication data is 2
        DataPtr: Address stored after reading instructions
        Done: Complete bit address setting
End
```

5 Design of Real time Data Monitoring System

5.1 System Operation and Development Environment

It is divided into user interface layer, business logic layer, and data storage layer.

1) User interface layer (web browser): This layer is the human-computer interaction layer, where management personnel access and operate the system through the browser;

2) Business logic layer (Web server): The business logic layer is used for user request processing, business logic control, page generation, database connection, etc., and is the core control layer of the system;

3) Data storage layer (database server): This layer is the fundamental guarantee for the implementation of system functions, serving as the warehouse for workshop data classification, storage, and management, and establishing data interaction with web servers.

The system development environment configuration is shown in Table 2.

Table 2. System development environment configuration

Database	Mysql5.1
Programming language	Java
Development tool	Eclipse4.7
Network environment	LAN
Client	Web
Server side	Server side: Microsoft Windows Server 2008 operating system, installed with MySQL 5.1 database, JDK10.0, Tomacat9.0 web server.

5.2 System Running Instance

The production data collection and processing system adopts a B/S architecture design. Workshop management personnel enter the corresponding website of the system in the browser and enter the system login interface. After the user enters their username and password and passes system verification, the system provides the corresponding system operation interface for user permissions based on the different visitor permissions, as shown in Fig. 4.

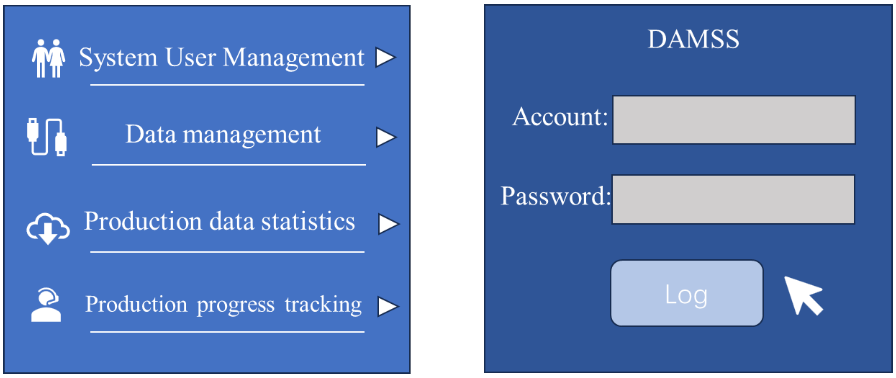

Fig. 4. System login interface

After entering the system, the working status of the machining center is a key data monitoring object. With the machining center as the monitoring object, the system provides a resource status query function for the machining center, which is displayed to workshop management personnel in a visual way. As shown in Fig. 5, the status of each machining center in the workshop is checked by the system's set status color to view the current status of the machine tool, and information related to sleeve parts, personnel, materials, processes, etc. in the current production of the machining center is obtained. The start time of the machining center status and the number of sleeve turning times are obtained through the installed counting terminal and historical data accumulation.

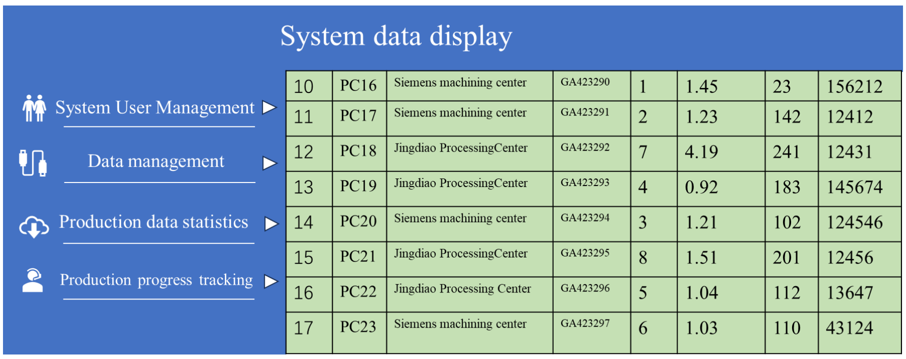

Fig. 5. System data display

This article establishes data transmission using industrial Ethernet, improving the reliability of data transmission, and eliminating the need for extensive modifications to existing equipment in enterprises. At the same time, electronic tags are bound to manufacturing resources, and remote and multi tag recognition can be achieved through RFID devices, enabling real-time viewing and collection of resource information without being affected by production environments such as oil pollution. By combining multiple data collection devices, real-time collection and transmission of workshop data can be achieved, reducing paper-based operations and manual error rates. By viewing through the system interface, you can grasp the production dynamics of the workshop.

6 Conclusion

This article focuses on the production and processing of sleeve parts, using Ethernet as a data transmission medium to complete data collection and monitoring of typical intelligent factory processing workshops. We have built various modules at the physical level, described the communication methods between various devices, and finally developed a data display system, which has preliminarily completed the design expectations and has great practical value for the design of similar production workshops.

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