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Design and Simulation of Express Sorting System Based on The PLC Techniques

Pengyuan Zhang[a], Wenxia Du[a,b], Xiuping Zhao[a,c*]

[a] College of Career Technology, Hebei Normal University, Shijiazhuang, Heibei,050024, China

[b] Hebei Provincial Innovation Center for Wireless Sensor Network Data Application Technology, Heibei,050024, China

[c] Hebei Provincial Key Laboratory of Information Fusion and Intelligent Control, Shijiazhuang, Heibei,050024, China

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ABSTRACT

With the rapid development of e-commerce, the sorting system are widely used in the logistics industry. However, the traditional manual sorting and express delivery have the characteristics of low sorting efficiency, high labor cost and high sorting error rate, which will result in an increased cost of express sorting. Accordingly, in this current work, an automatic and intelligent express sorting control system was introduced based on programmable logic controller (PLC) techniques. The express sorting system is composed of a Siemens S7-1214CPU, a touch screen, a scanning gun and other components, and a combination of the conveyor belts and sensors was used to determine the direction of express action. The express sorting function and the counting function of express were achieved using the simulation and the self-increasing module, respectively. The realization of the functions and each subsystem provide a theoretical support for the design and optimization of the automatic sorting system.

1. Introduction

Automatic sorting is used to transport machinery and equipment in modern production industry, including our daily life. The materials to be scanned on the supermarket cash register are transported to the scanning area, and the letters are automatically sorted at the post office and the sorted items are transported to the designated location. With the development of modern science and technology, automatic sorting technology is more widely used in the modern market. The automatic sorting system integrates the application of programmable controller, mechanical transmission and pneumatic control, man-machine interface, motor drive and other technologies.(e.g.,Alboteanu L, Manolea G, Ravigan F.,2018).

The application of programmable controller technology is an important part of automation. The system with automatic control and monitoring functions is designed to meet the actual application environment. The system functions include product sorting, processing, display and human-computer interaction. A stable control system will affect the smooth operation and control function of the whole system, thus affecting the control quality of the whole process of the sorting system, which is also the soul of the automatic sorting system.(e.g.,L. Huimin.,2023).

The development of the internet of things is making online shopping more and more convenient.(e.g.,C. Chen, J. Cheng, B. Ma and Z. Wang.,2023). The express delivery industry has become an important link between merchants and consumers.As one of the most important links in the express delivery industry, express sorting plays a decisive role in the efficiency and service quality of express delivery enterprises. The traditional manual sorting method has been unable to meet the growing demand for express delivery, PLC has the advantages of simple structure and strong operability. It can be applied to the sorting system, and can achieve excellent control effect and expected target depression.(e.g.,Z. Zhou and Q. Zhou.,2022). The design and manufacture of the express sorting system based on PLC has important value. Compared with traditional manual sorting, automatic sorting has the advantages of high efficiency, low error rate, many sorting points, unmanned industrial operation, etc.(e.g.,L. Huimin.,2023). Therefore, the study of automatic sorting system is of great significance for enterprises to improve production efficiency and achieve capacity upgrading.(e.g.,Wang F, Zheng J, Tian X, et al.,2018).

In this study, this paper combines automatic sorting and bar code collection by PLC, through PLC to identify express, input information,(e.g.,C. Chen, J. Cheng, B. Ma and Z. Wang.,2023), and then carry out intelligent sorting, to realize the automation and intelligence of the sorting process.

* Corresponding author.
E-mail addresses: zhaoxiuping07111@sina.com (X. Zhao)
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2. System Design

2.1 Control Requirements

According to the actual demand in the express industry, the work flow of the scheme, and functional requirements of the express sorting system was determined and realized. For the system function, read the shortcut bar code is the key, which specific control requirements can be expressed as follows:

(1)How to scan and read bar code information.

(2)How to design the sorting process, which can ensure the program is correct and can be connected to the simulation.

(3)How to realize the counting function when the express arrives at the specified setting.

(4)How to realize the smooth movement of the express in the simulation interface.

2.2 System Composition And Working Principle

The Siemens S7-1214CPU was used as the control center, TIA Portal Vl8 was used for programming design, a touch screen was used to realize function simulation, the code gun was scanned through RS232. In addition, a communication connection was developed using the PLC, and a point-to-point RCV_PTP was used to receive messages, which can determine the belonging place of the express. the direction of express action, start and stop of the sensor, and running time of conveyor belt were specified by the combination of the conveyor belt and sensor, the high-level pulse signal and the delay time pulse mode were used to specify the sensor start and stop and the conveyor belt running time, respectively. The sorting and counting function of the express was realized using simulation and the self-increasing module, respectively.

2.3 Control Scheme

As illustrated in Fig.1, the control center of the express sorting system was a PLC control system. The input of the express sorting system was composed by photoelectric sensors, limit switches, and bar code scanners. The operating conveyor was the output of the system.

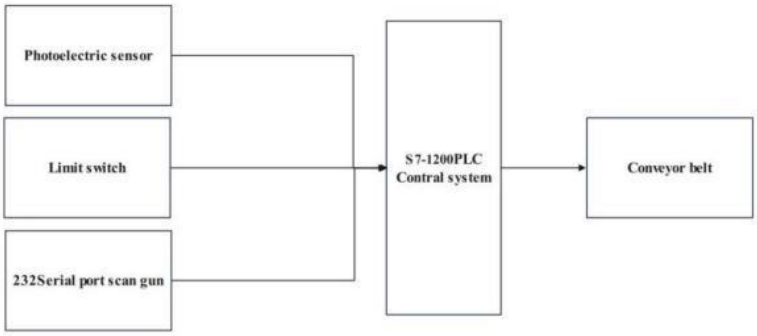

Fig. 1. The scheme of system control

2.4 System Flowchart

Based on the design idea, the system flow chart shown in Fig.2 was developed to complete the whole system workflow.

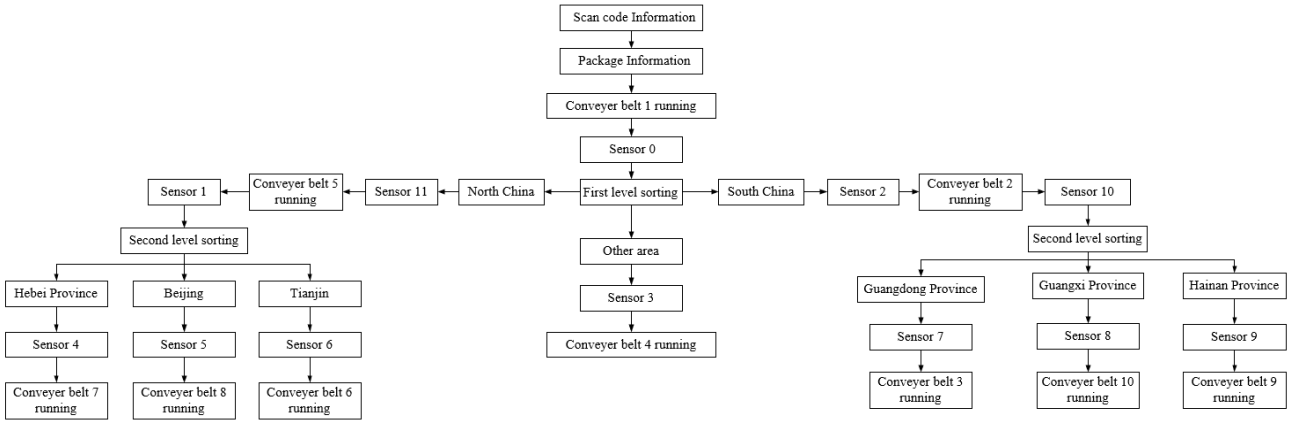

Fig. 2. System flowchart

As shown in Fig.2, the code is scanned by a scanning gun, when the express reaches the scanning position, the conveyor belt starts to run after the scanning code is completed and the sensor 0 reaches the sorting center at the first level, and determines whether to go to North China, South China or other regions according to the bar code information. When going to North China, sensor 11 works to make the conveyor belt 5 run, and when sensor 1 works, it reaches the secondary sorting center When going to Hebei Province, sensor 4 works and conveyor 7 runs to the designated location.

2.5 Hardware system structure design

In this paper, the overall design of the hardware adopts the identification structure and the execution structure of three parts as known in Fig.3.

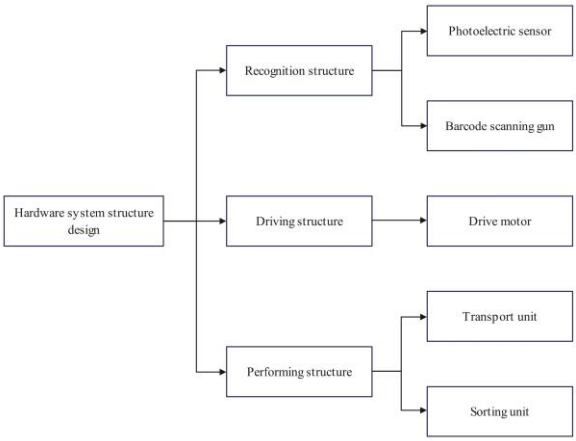

Fig.3. Hardware system structure design

(1) The recognition structure consists of photoelectric sensor and bar code scanning gun. The scanning gun is used to identify the bar code on the express and read the bar code information to transmit to the PLC; photoelectric sensors are used to identify the delivery location and detect whether the delivery has arrived at the specified location.

(2) The drive structure consists of a drive motor. The drive motor is used to control the operation of the sorting platform and conveyor belt,and the speed of the motor and the direction of rotation are controlled by PLC.

(3) The execution structure consists of a transfer unit and a sorting unit. The transmission unit is composed of multiple conveyor belts to ensure smooth and stable sorting process; the sorting unit consists of three sorting platforms to ensure that the designated express is sorted to the designated area.

2.6 Address Assignment

In order to make the subsequent programming to be clear and concise, the register address of each component was set in the simulation. The address information for each component is shown in Tab.1.

Tab.1. Address assignment

Name	Address	Name	Address
Bar code scanning gun	I0.0	Conveyor 1	Q0.0
Start button	I0.1	Conveyor 2	Q0.1
Stop button	I0.2	Conveyor 3	Q0.2
Reset button	I0.3	Conveyor 4	Q0.3
Sensor 0	M2.0	Conveyor 5	Q0.4
Sensor 1	M2.1	Conveyor 6	Q0.5
Sensor 2	M2.2	Conveyor 7	Q0.6
Sensor 3	M2.3	Conveyor 8	Q0.7
Sensor 4	M2.4	Conveyor 9	Q1.0
Sensor 5	M2.5	Conveyor 10	Q1.1
Sensor 6	M2.6	Storage 11	M6.2
Sensor 7	M2.7	Storage 12	M6.3
Sensor 8	M3.0	Storage 13	M6.4
Sensor 9	M3.1	Storage 14	M6.5
Sensor 10	M3.2	Storage 15	M6.6
Sensor 11	M3.3	Storage 16	M6.7
Storage 1	M5.0	Storage 17	M7.1
Storage 2	M5.1	Storage 18	M7.2
Storage 3	M5.2	Storage 19	M7.3
Storage 4	M5.3	Storage 20	M7.4
Storage 5	M5.4	Storage 21	M7.5
Storage 6	M5.5	Storage 22	M7.6
Storage 7	M5.6	Storage 23	M7.7
Storage 8	M5.7	Storage 24	M8.1
Storage 9	M6.0	Storage 25	M8.2
Storage 10	M6.1	Storage 26	M8.3

2.7 Communication Module Introduction

As the core of the system design, the information communication between the scanning gun and PLC control center was realized by the point-to-point RCV_PTP instruction in the communication processor, which is used to collect the bar code information. The introduction of the RCV_PTP instruction is shown in Fig.4, and the interface parameters of the module are shown in Tab.2.

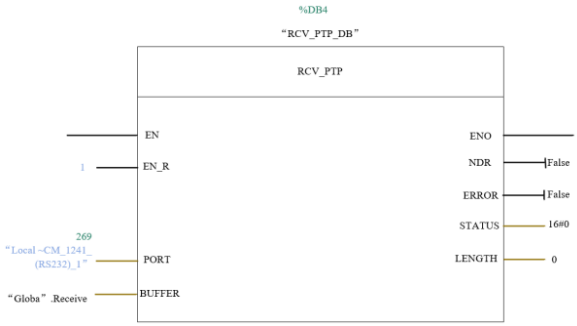

Fig. 4. Communication module

Tab.2 describes the interface parameters of the module.

Tab.2. RCV_PTP Parameter description table

Parameter	Statement	Data type	Memory area	Explain
EN_R	Input	BOOL	I/Q/M/D/L or Constant	Rising edge enables receiving
PORT	Input	PORT	I/Q/M/D/L or Constant	Identification communication port
BUFFER	Input	VARIANT	I/Q/M/D/L or Constant	Points to the start address of the receive buffer
NDR	Output	BOOL	I/Q/M/D/L	State parameter
ERROR	Output	BOOL	I/Q/M/D/L	State parameter
STATUS	Output	WORD	I/Q/M/D/L	State of instruction

LENGTH	Output	UINT	I/Q/M/D/L	The length of the message in the receive buffer

3. Simulation And Verification

3.1 Building Of Sorting System Simulation Model

The system simulation model developed by PC Station in TIA Portal V18 is shown in Fig.5.

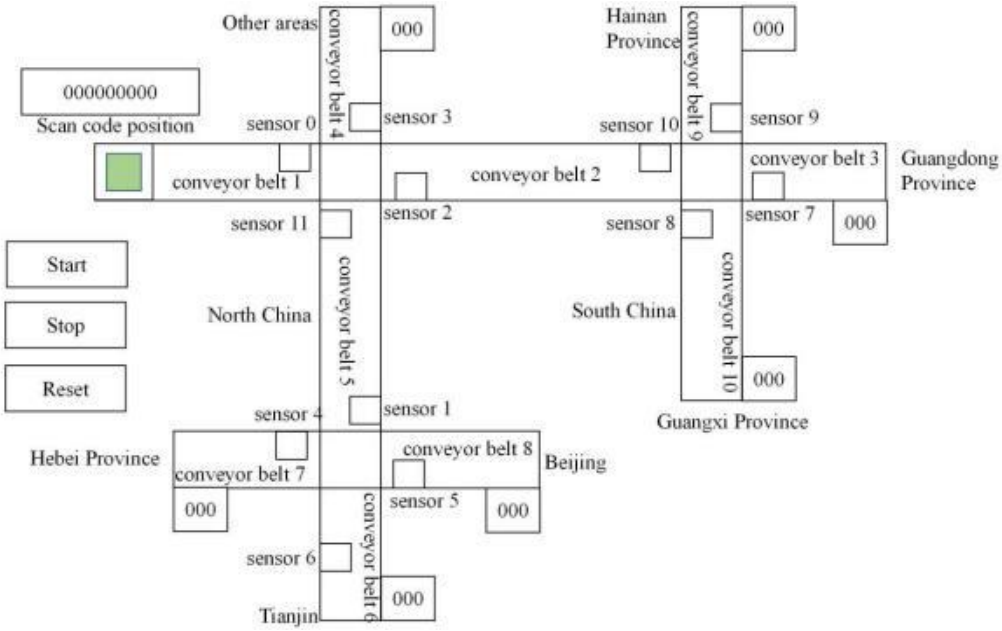

Fig. 5. Simulation model diagram

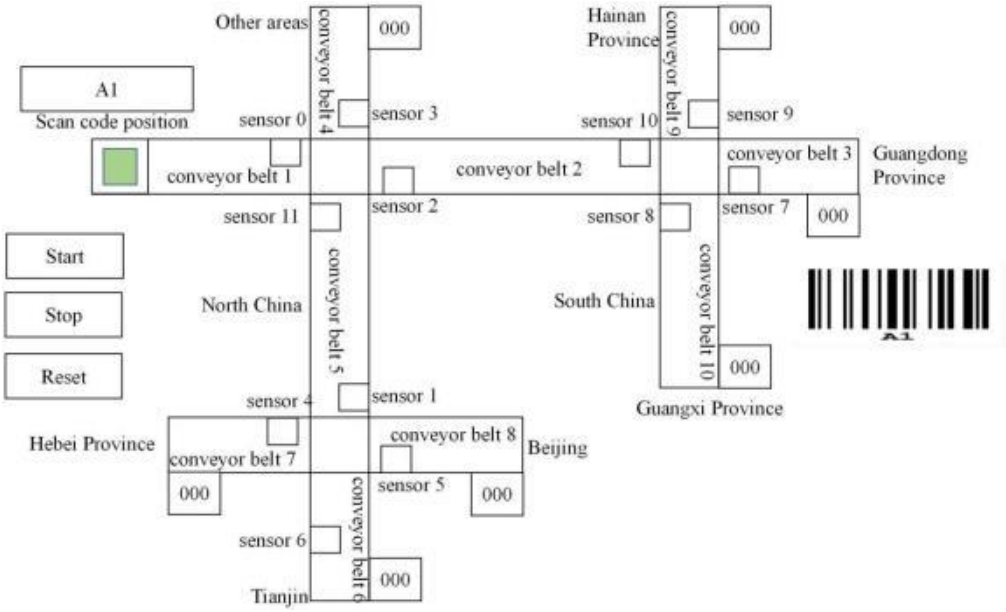

Fig. 6. Scanning simulation

It can be seen from Fig.5 that the express sorting system can be used to sort the express packages, which belonging place is North China, South China and other areas. 10 conveyor belts were used to deliver express packages. 12 sensors were also added in the system to identify the location of express packages. For North China, Beijing city, Tianjin city and Hebei province were chosen, and with regard to South China, Guangdong province, Guangxi province and Hainan province were selected to test the accuracy of the express sorting system. Bar code information A1 in the program represents the express to Beijing, A2 represents the express to Hebei Province, A3 represents the express to Tianjin, B1 represents the express to Guangdong Province, B2 represents the express to Guangxi Province, B3 represents the express to Hainan Province, C represents the express to other areas.

3.2 Simulation Result of Code Scanning Process

As shown in the Fig.6. The code gun was used to scan the bar code, which is shown on the right side of the system. When the scanning process is completed, the bar code information will be displayed on

the IO field, which is above the scanning position.

As shown in Fig.6, when the scanning gun scans the bar code, bar code information will be displayed in the IO field above the scanning position.

3.3 Sorting Process

The bar code information was sent to the PLC control center, which can obtain the sorting position of the package. The sorting process is shown in Fig.7.

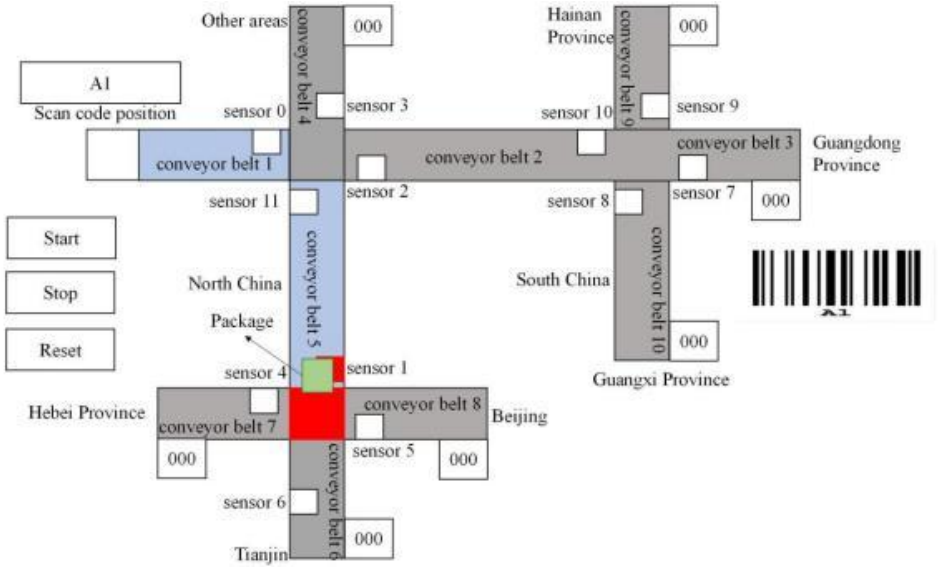

Fig. 7. Sorting process diagram

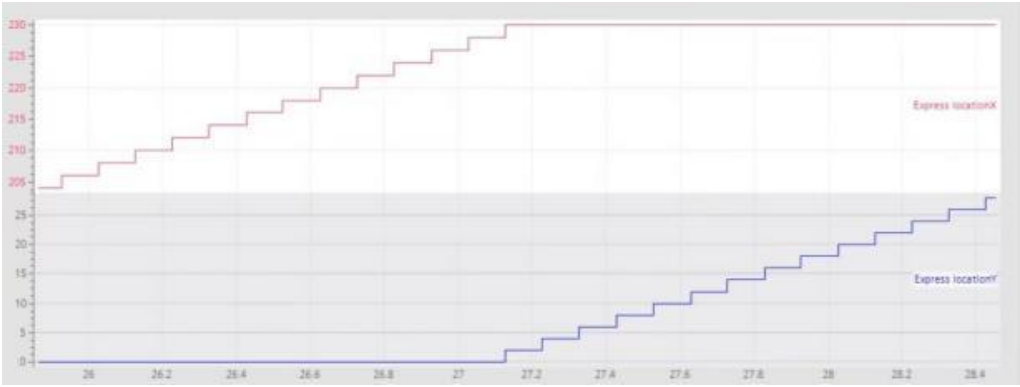

Fig. 8. Coordinate trajectory diagram

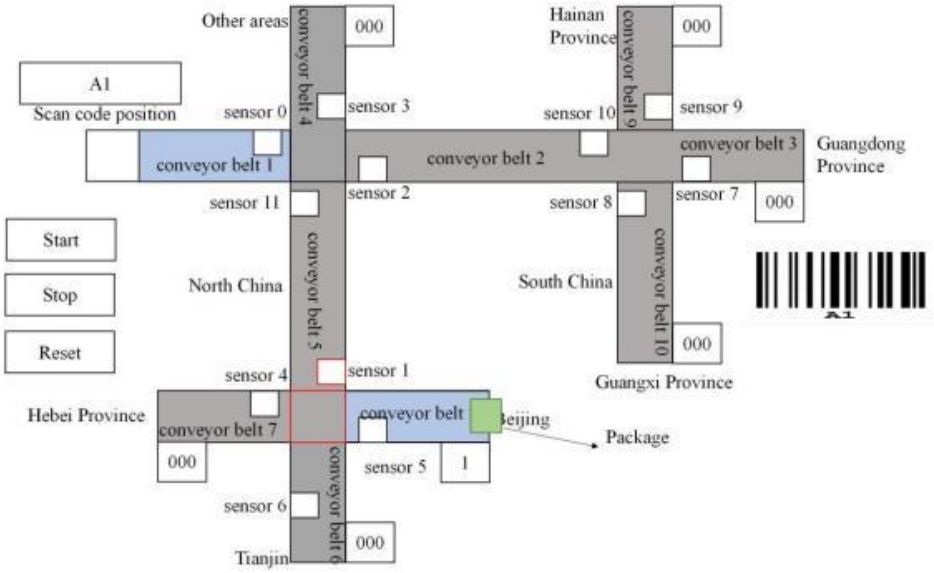

Fig. 9. Counting results

As shown in Fig.7, the conveyor belt and sensor used in the sorting process light up when working, and the two are combined to complete the entire sorting process.

In order to further display the moving process of the express on the simulation interface, the express location was also simulated in the software, as shown in Fig.8. The sampling period of the express location variable is 100ms, which can make the express running process more stable.

Fig.8 shows the coordinate track of the express location when the express arrives at the first level sorting center and goes to Hebei Province. The horizontal axis represents the sampling time and the vertical axis represents the coordinate information of the express location, The sampling period of the running track is 100ms, the red represents the X trace information of the horizontal coordinate, and the blue represents the Y trace information of the vertical coordinate.

3.4 Simulation Results Of Counting Function

When a package arrives at the sorting position, the counting module and the number shown in the IO fields of which will increase by one. Taking the package in Beijing as an example, the counting module for a successful sorting is shown in Fig.9.

As shown in Fig.9, after the express delivery arrives in Beijing, the IO fields below Beijing will automatically increase by l, which is used to calculate the number of express deliveries arriving there.

4. Summary

Based on the requirements of the logistics industry, an efficient and intelligent sorting system with the characteristic of appropriate sorting rate and sorting efficiency has been designed and simulated, which can significantly improve sorting efficiency and accuracy. The results obtained by this model indicate that the express delivery operation process is stable and the components can work in an orderly manner.

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Pengyuan Zhang received his bachelor degree of electrical engineering and automation of Hebei Normal University in 2024.

Wenxia Du obtained her master degree and doctor degree of control theory and control engineering major from the institute of electrical engineering of YanShan University in 2001 and 2012 respectively. She is currently working in Hebei Normal University. Her main research interests are in area of neural network control and predictive control of nonlinear system, the fault diagnosis based on data driven is her new research direction in recent years.

Xiuping Zhao obtained her master degree of Mechanical Manufacturing and Automation from the institute of Manufacture of SiChuan University in 2001. She is currently working in Hebei Normal University. Her main research interests are in area of integration of Mechanics and electrics, Mechanical Manufacturing and Automation.