Multi-functional Conveyor Sorting Device Based on Book Information Processing

Design Specification

ABSTRACT

In recent years, the party and the government have vigorously promoted the construction of public cultural service system. With the implementation of a series of plans such as "basic establishment of public cultural service system" and "equalization of basic public services", Chinas public library cause has also ushered in great development, but with it, it takes a lot of time and energy to return and sort out large-scale books. At present, most libraries still rely on manual sorting, and the sorting task is very heavy and timeliness is poor, which cant meet the requirements of rapid circulation of documents, thus making the reading needs of many readers difficult to meet.

The intelligent book sorting system proposed in this work is a fully automatic and intelligent book sorting device, which can sort books in batches, continuously and intelligently on the basis of saving manpower and material resources, and can effectively solve the problems of disordered book sorting. The overall structure of the system mainly consists of three systems: mechanical execution system, image acquisition system and data processing system. Through the image acquisition system, the article information carried on the conveyor belt and the first identification number of the pallet where the article is located are picked up and transmitted to the data processing system, and according to the book discharge instructions and requirements, the universal multifunctional manipulator is used to grab and lay the book. Among them, the data processing system is the core of the whole work, and the placement, sorting and grabbing of books are completely completed by the mechanical control part.

The intelligent book sorting system is of great significance to solve the problems of complicated book sorting process and large consumption of human resources.

Keywords: smart books, Mechanical transmission; Image acquisition; Information processing

Catalogue

1 Background

In terms of automatic article sorting robot technology, foreign countries started earlier, especially in developed countries represented by the United States, Japan and Europe, the application of sorting machines shows the characteristics of increasingly high degree of automation. GermanyS S + S company is a typical example. The automatic sorting machine they developed uses high-frequency detection coils, laser identification technology, high-speed line scanning cameras and other technologies to identify and locate impurities in materials. When impurities are detected, different rapid reaction mechanical or pneumatic rejection devices are used to separate impurities. In process control and monitoring, advanced dual-channel digital signal processor is adopted. Since the introduction of automatic sorting technology in 1970s, China has continuously absorbed foreign advanced experience, developed independently, and continuously developed new products according to various needs with the worlds advanced technology. Nowadays, Chinas automatic sorting technology is the same as that of foreign countries. Compared with Chinas automatic sorting technology, Chinas automatic sorting technology is more in line with its own characteristics. For the same functions, Chinas automatic sorting technology products have more affordable prices. Generally speaking, the application of sorting machines in China is characterized by low intensive degree and not extensive application range of automation systems and equipment.

In recent years, the party and the government have vigorously promoted the construction of public cultural service system, and successively put forward a series of objectives and requirements such as "basic establishment of public cultural service system" and "equalization of basic public services". With the implementation of the goal and the implementation of the plan, Chinas public library has also ushered in great development. Especially in the aspect of book sorting, various libraries in cities, schools and other places have been established and expanded one after another, but with it, a lot of time and energy are spent in the return and sorting of large-scale books. However, at present, most libraries still rely on manual sorting, and the sorting task is very heavy and timeliness is poor, which cant meet the requirements of rapid circulation of documents, thus making the reading needs of many readers difficult to meet. The sorting machines used by a few libraries are mainly composed of imported book sorting machines and book sorting systems transformed from logistics sorting machines. Among them, if the imported book sorting machine encounters any failure,

the whole system needs to stop waiting for maintenance, which will affect the book sorting; However, the sorting machine transformed from the logistics sorting machine occupies a large space and the logistics sorting device causes great damage to books in operation.

Therefore, this work aims to design a device that integrates intelligent identification, transmission, and sorting. The device adopts a mode that integrates collection, identification, transmission, and sorting. During work, only books need to be placed directly on the work surface, no other operations are required, which greatly improves work efficiency. Moreover, the self-designed universal multi-functional gripper is adopted during sorting, and the gripper is designed to fit well with the book and will not cause damage to the book. Each part is modularized, which not only reduces the weight burden of each part, improves the stability and durability of the device, but also facilitates maintenance in case of damage. Moreover, the whole device adopts detachable segment type, which is suitable for libraries of various sizes and has good adaptability.

2 Product technical principles and related selection

2.1 Control principle of moving part

The conveying and sorting system realizes the conveying and grabbing of books through the cooperation of conveyor belt and six-degree-of-freedom mechanical gripper; The lifting system uses a transportation platform composed of screw motors, paddles, rubber bands and steel columns. Through the control of the electronic control system, the two screw motors rotate to drive the platform to move up and down. When the object moves near the distance detector, the detector receives the information, the platform stops moving, returns the information to the data processing system, and after discrimination, if it matches, sends an instruction to the material dialing assembly and the barrier assembly, and rotates and dials out the book under the driving of the transmission wheel set. The conveyor belt operation system adopts a multi-rod side-by-side connection method, and an infrared sensing device is installed on the aluminum frame, which can sensitively sense the position of objects and provide position information for the subsequent mechanical gripper to grab books. The specific detailed process will be explained in Section 3.

2.2 Software part control principle

In order to reduce the difficulty of underlying development, Arduino is used for corresponding development. Arduino has rich sensor library files, which reduces the difficulty of development. Moreover, arduino uses c + + to develop. Because of the object-oriented characteristics of c + +, by constructing various classes, the coupling between codes is greatly reduced, the reusability of codes is improved, and it is convenient for maintenance and subsequent transformation and upgrade. This system mainly constructs the following classes:

(1) The three classes StrongerServo, Drive74HC595, and mineTimeCounter mainly provide more powerful underlying support, which facilitates subsequent development. StrongerServo mainly provides support for steering gear control. Because arduinos open source library Servo control is too rude, and completing a fixed action requires a lot of code support, which wastes a lot of cpu time. StrongerServo introduces the parameter of assigning action tasks in advance and the action execution speed to query and execute predetermined actions, which makes the control of steering gear softer and greatly reduces the occupation of cpu time.

(2) Drive74HC595 is mainly used to drive the 74hc595 chip, encapsulating

relevant logic and improving reusability. mineTimeCounter, traditional microcontroller programming delay generally uses timing interrupt or delay () delay. Using delay results in wasted effective cpu time and missed responses to events, while using timed interrupts If there are multiple different cycles of tasks, timed interrupts will be difficult to implement unless the frequency of timed interrupts is greatly increased. The general solution to this problem is to use a real-time operating system, but the weak performance of arduino limits this idea, while mineTimeCounter solves this problem in a simpler way. Through the built-in millis () function of arduino, the time is set in advance to query whether the task is completed, which takes up a small amount of resources and achieves ideal results. It is used in both libraries MineQrCodeReader and StrongerServo.

(3) MadonGProtocol establishes a simple communication protocol, which provides support for the exchange of data and instructions between the host and the slave.

(4) MineQrCodeReader, due to the use of the QR code identification module, this module will send the QR code to arduino through the serial port after parsing the QR code, but this information cannot be used directly. The information received by the serial port can be parsed through MineQrCodeReader to get the information we need.

(5) SortMachineProtocol further abstracts Drive74HC595 and simplifies the related logic. Drive74HC595 is a more general class and can be used for multiple projects. However, SortMachineProtocol has performed more specific processing and basically loses its universality. It is only designed for this project, but greatly simplifies the related logic.

The conveyor belt sends the item, and after the object is detected through the photoelectric switch, the QR code module scans it, analyzes the relevant information through the MineQrCode Reader, and then delegates the task to the relevant slave according to the predetermined task list. After the slave receives the task, it waits for the object to reach the designated position, then loads the predetermined action, completes the sorting, then establishes master-slave communication, and logs out the task. The specific test contents are shown in Table 2-1.

Table 2-1 Test Protocol

Power Supply, MCU and Relay
Is the microcontroller working properly

Whether a bleed diode is added to the relay control circuit
Whether the transistor in the relay control circuit is broken down
Whether the diode in the relay control circuit is broken down
Power supply, use voltmeter to measure whether the voltage is within the predetermined range
Communication section
Whether the serial port can output normally
Whether the 74 series chip is working properly and can display the identification code from the host computer
Motor control part
Is the motor normal
Whether a bleed diode is added to the motor drive circuit
Whether the transistor of the motor drive circuit is broken down
Steering gear part
Whether the servo gear corresponds normally
Whether the steering gear signal line is connected normally
Is the steering gear in good condition
Two-dimensional code recognition part
The two-dimensional code module sends information normally
Is the data parsed correctly
Photoelectric switch part
Whether the photoelectric switch can respond normally
Is the detection distance of photoelectric switch reasonable

2.3 Product parameters and selection

2.3.1 Technical parameters of steering gear

This device adopts MG996R servo gear, and its main function is to provide rotational power for the mechanical arm, which is convenient for the mechanical arm device to rotate 360 ° without dead angle.

Table 2-2 Related parameters

Product type: MG996R servo gear
Product torque: 9kg/cm (4.8 V), 11kg/cm (6V)
Product speed: 0.19 sec/60 ° (4.8 V), 0.18 sec/60 ° (6V)
Rotation angle: 180 °
Working voltage: 4.8 ~ 6V
Gear Form: Metal Gear
Dead zone setting : 5 us (microseconds)
Product weight: 55g
Product Dimensions : 40.7 mm × 19.7 mm × 42.9 mm

Taking advantage of the characteristic that the rudder can rotate along a certain angle, it is loaded on each sub-node of the mechanical arm, so as to realize the flexible rotation of the mechanical arm and solve the problem that the grasping angle of the traditional mechanical gripper is limited.

2.3.2 Chip technical parameters

The Arduino Mega 2560 R3 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (14 of which can be used as PWM outputs), 16 analog inputs, 4 UART (hardware serial ports), 16 MHz crystal oscillator, USB connection, power jack, ICSP header and a reset button. Simply connect it to your computer using a USB cable or start it up using an AC-DC adapter or battery.

In order to communicate with multiple modules and improve the speed of multi-task coordination control, we chose this chip as the main control chip. The advantage of this chip is that it runs the fastest under the same system clock; The Flsah, EEPROM, and SRAM inside the chip have large capacities; All models of Flash and EEPROM can be programmed repeatedly, and all support online programming (ISP); Internal RC oscillator with various frequencies, automatic reset on power, watchdog, start-up delay and other functions, and zero peripheral circuit can also work; Rich in resources, generally integrating AD and DA analog-digital devices; PWM; SPI, USART, TWI, I2C communication ports; Rich interrupt sources, etc.

Table 2-3 Related parameters

Microcontroller	ATmega2560

Operating voltage	5V
Input voltage	(Recommended) 7-12V
Input voltage	(Limit) 6-20V
Digital I/O pins	54 (14 of which provide PWM output)
Analog input pin	16
DC current per I/O pin	40mA
DC current at 3.3 V pin	50mA
Flash memory (Flash Memory)	256KB (of which 8KB is used by the bootloader)
SRAM	8KB
EEPROM	4KB
Clock speed	16MHz

2.3.3 Flash Memory (Flash Memory, variant of EEPROM)

The stored data information that can still be maintained in case of power failure is divided into NOR type and NAND type flash memory (NAND type is more common, generally referred to as NAND type): the basic storage unit of memory and NOR type flash memory is bit, and users can randomly access any bit of information. The basic memory unit of NAND flash memory is Page. The effective capacity of each page is a multiple of 512 bytes. The NAND type flash memory performs an erase operation (erase one by one) in units of blocks. The write operation of flash memory must be performed in a blank area. If the target area already has data, it must be erased first and then written, so the erase operation is the basic operation of flash memory. Generally, each block contains 32 512-byte pages with a capacity of 16KB; When large-capacity flash memory uses 2KB pages, each block contains 64 pages with a capacity of 128KB. In short, RAM data cannot be saved when powered off, so it is often used for caching between CPU and peripherals; The data of EEPROM is not lost when powered down, and it is used for programming reading and writing; Sometimes due to the large amount of data that needs to be rewritten, Flash Memory (NAND type) appears on the basis of EEPROM.

2.3.4 EEPROM

Live Erasable Programmable Read-Only Memory-A memory chip that does not lose data after power failure. EEPROM can erase existing information and reprogram it on computers or special devices. Generally used in plug and play. The erasure of

EEPROM does not require the help of other devices. It uses electronic signals to modify its content, and Byte is the minimum modification unit. It is not necessary to wash all the data before writing, completely getting rid of the constraints of EPROM Eraser and programmer.

2.3.5 SRAM

SRAM does not require a refresh circuit to save the data it stores internally. DRAM (Dynamic Random Access Memory) needs to be refreshed and charged every once in a while, otherwise the internal data will disappear. Therefore, SRAM has higher performance, but SRAM also has its shortcomings, that is, its integration is low. DRAM memory of the same capacity can be designed to be smaller in size, but SRAM requires a large size and consumes a lot of power. Therefore, SRAM memory occupies a part of the area on the motherboard. SRAM is fast but expensive. Generally, small-capacity SRAM is used as the cache between higher-speed CPU and lower-speed DRAM. The chip is embedded with high-quality Flash program memory, which is easy to erase and write, supports ISP and IAP, and is convenient for product debugging, development, production and update. The embedded long-life EEProm preserves critical data for a long time and avoids loss during power outages. On-chip large-capacity RAM can not only meet the needs of general occasions, but also more effectively support the use of high-level languages to develop system programs, and can expand external RAM like MCS-51 single chip microcomputer. It has a variety of independent clock dividers for URAT, I2C, and SPI respectively. Among them, the prescaler with up to 10 bits cooperated with the 8/16-bit timer can set the frequency division coefficient through software to provide various grades of timing time. Has a variety of power-saving sleep modes,But also can run at a wide voltage (5-2.7 V), has strong anti-interference ability, has a variety of power-saving sleep modes, and can run at a wide voltage (5-2.7 V), and has anti-interference ability, and has a variety of power-saving sleep modes, and can run at a wide voltage (5-2.7 V), and can run at a wide voltage, and has a strong anti-interference ability

3 Product design

3.1 Product design purpose

At present, the sorting work of most libraries depends on manual sorting. The sorting task is very heavy and timeliness is poor, which cant meet the requirements of rapid circulation of documents, thus making the reading needs of many readers difficult to meet. Generally speaking, the current library sorting technology has the following shortcomings:

(1) At present, most libraries still rely on manual sorting, and the sorting task is very heavy and timeliness is poor, which cant meet the requirements of rapid circulation of documents

(2) At present, the technical development of book sorting in China is not mature, the degree of automation is low, and the efficiency of book return affects the needs of users.

(3) The existing book sorting devices are prone to jam during the sorting process.

This work aims to provide a fully automatic and intelligent book sorting device. The advantage of the intelligent book sorting device is that it can sort books continuously and in large quantities, and is not limited by time, human physical strength and other factors, so as to meet the book returning needs of teachers and students to the maximum extent.

This work adopts image recognition technology, which is highly integrated and automated, and can reduce sorting cost and damage rate, and improve sorting efficiency. In terms of overall structure, it consists of three systems: mechanical execution system, image acquisition system and data processing system. The mechanical transfer and sorting system constitutes the hardware part of the equipment. The sorting system includes a conveyor belt and a plurality of universal multifunctional grippers for grasping books; An image acquisition system that acquires the information of the articles carried on the conveyor belt and the first identification number of the tray where the articles are located, and then returns the information to the control system after acquisition; The data processing system receives the article information collected by the image acquisition module and the part of the first identification number, and controls and realizes the mechanical action. The data processing system is the core of the whole work, and the placement, sorting and grabbing of books are completely completed by the processing system.

The intelligent book sorting system is of great significance to solve the problems of complicated book sorting process and large consumption of human resources.

3.2 Product structure design

This equipment consists of five parts: mechanical transmission system, image acquisition system, lifting mechanism, mechanical sorting system and data processing system.

Figure 3.1 Product structure composition

Mechanical transmission mechanism, lifting mechanism and mechanical sorting system constitute the hardware part of intelligent equipment, and image acquisition system and data processing system constitute the software part of intelligent equipment.

The mechanical execution system includes a conveyor system and a conveyor belt pressing device. The conveyor belt running system adopts the mode of multi-rod side-by-side connection, which ensures the stability of the whole conveyor belt running and the safety of articles on the premise of lightweight. The conveyor belt pressing device is used for fixing the connecting rod on the mounting bracket, the connecting rod is slidably arranged with a guide block, the guide block is arranged with a plurality of groups of long rod connecting pieces arranged in the vertical direction, and the bottom of the long rod connecting piece is arranged on the gasket support plate.

The image acquisition system transmits the item information to the background intelligent data processing system, judges whether it is needed after software processing, and then sends the instruction to the electronic control system, and then controls the mechanical execution system for sorting. The function of the control device is to identify, receive and process the sorting signal, instruct the sorting device according to the requirements of the sorting signal, and automatically classify the goods according to the variety of goods.

The background intelligent data processing system and electronic control system

constitute the software part of intelligent equipment. The electronic control system collects and processes related signals through each functional module, realizes the information interaction between the intelligent sorter and the upper computer software, operators, environment and mechanical actuators, in which the motor drive module and the main control module communicate with each other using programming language. The display control module, the radio frequency module and the main control module are connected through a serial port.

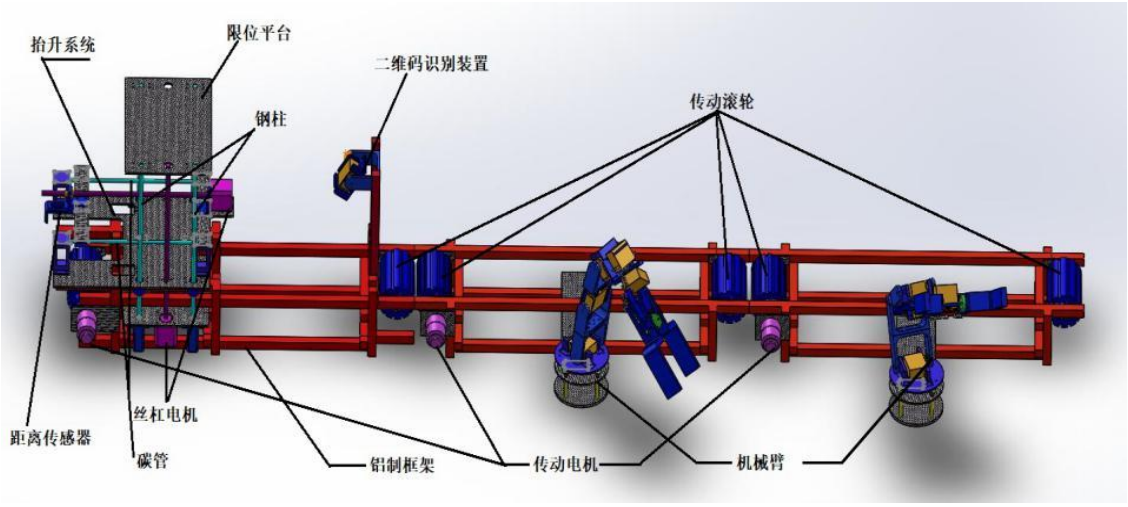

Figure 3.2 Product mechanical structure

3.2.1 Mechanical transmission system

Mechanical conveying system: It consists of transmission system and conveyor belt pressing device. The transmission system consists of motor, transmission wheel set, transmission compression rod, support rod and other parts. The supporting part adopts the mode of multi-rod side-by-side connection, which ensures the stability of the whole conveyor belt and the safety of articles on the premise of lightweight. The motor is fixed on two left and right four-hole supports, connected by four hollow round rods in the middle, and two freely movable fixing devices are installed on the bottom surface. The conveyor belt pressing device comprises a mounting bracket, the upper part of the mounting bracket is processed with a vertical slideway, a connecting rod passes through the slideway, a positioning device is arranged on the connecting rod, the positioning device is used for fixing the connecting rod on the mounting bracket, a guide block is slidably arranged on the connecting rod, a plurality of groups of long rod connecting pieces arranged in the vertical direction are arranged on the guide block, and the bottom of the long rod connecting pieces is arranged on the gasket support plate. Mechanical sorting system: The mechanical arm adopts six

degrees of freedom, which can realize grasping in all directions without dead angles. It adopts MG996R servo gear, which has a large directional rotation angle and can bear large force. The connection is connected with bearings and flanges, which has less resistance, faster speed and less position requirement. A gripper that fits better with the book is designed at the gripper, which protects the integrity and beauty of the book on the basis of ensuring accurate gripping.

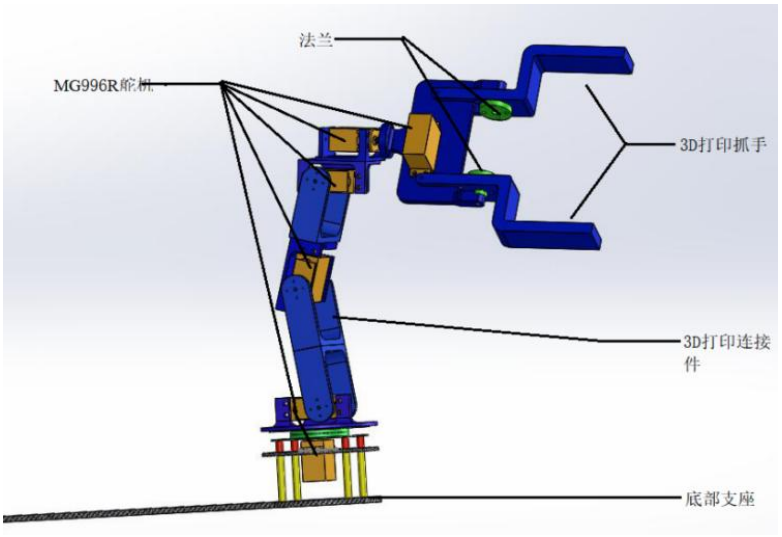

Figure 3.3 Mechanical gripper

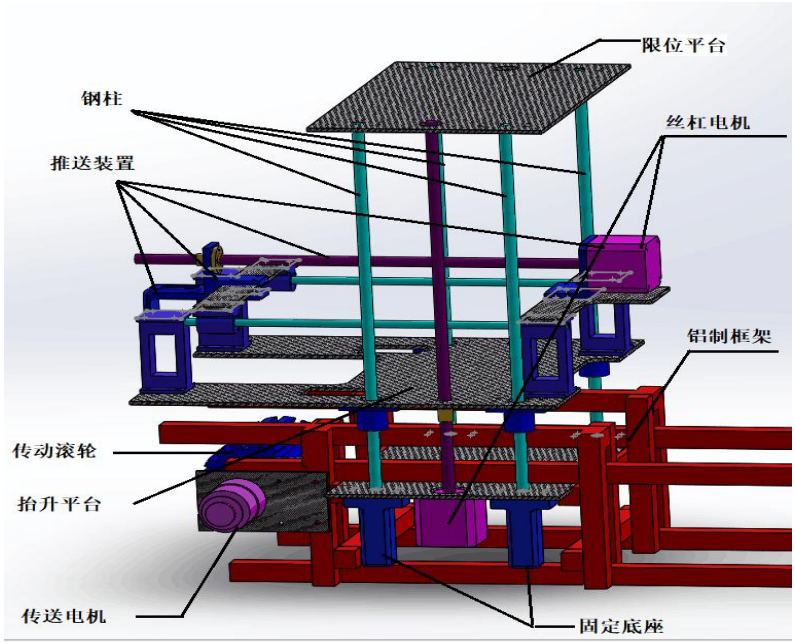

Figure 3.4 Lifting Mechanism

3.2.2 Image acquisition system

The image acquisition module of the apparatus includes an image processing device and a two-dimensional code recognition device. The two-dimensional code recognition device is configured to receive the package information collected by the

image acquisition module and the first identification number, and determine key characters in the package information. Through the sensor, the shape, color, size and other characteristics of the object are identified and transmitted to the single chip microcomputer control system to achieve accurate identification. The external color and positioning sensors communicate with the main single chip microcomputer through the serial port, and the serial idle interrupt is added to the program to cooperate with DMA to receive data, save the single chip microcomputer resources, improve the running speed, and save the single chip microcomputer bus resources while ensuring the data accuracy.

This equipment uses universal two-dimensional code recognition. Two-dimensional code technology is an electronic tag technology developed by using photoelectric technology and computer technology. It has the advantages of good tracking, large storage capacity and low cost. When designing the sorting technology system of two-dimensional code, because the two-dimensional code has the characteristics of large information storage, the sorting number can be added to the two-dimensional code, and the sorting number can be set as the information of books. The two-dimensional code scanning module mainly reads the two-dimensional code information, and then transmits the obtained information. Compared with other collective recognition modules of color, character and shape recognition, the two-dimensional code module is smaller and faster, and we use two-dimensional codes more in daily life, which is convenient for administrators to encode.

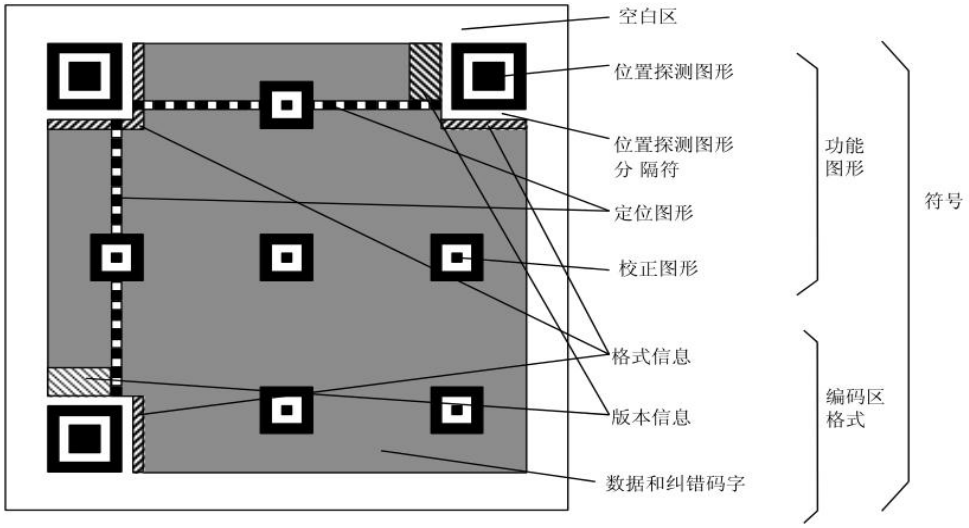

Figure 3.5 QR code encoding

In order to make the error rate of the equipment extremely low, sensitive in response, and match with other equipment and other commodities, this system adopts

a two-dimensional code identification device; In the selection of the position of the two-dimensional code recognition device, the height matches the recognizer, and the best recognition distance is obtained through a large number of experiments. The best effect in matching with QR code recognition. In the lateral position, through experiments as well as numerous calculations. Make the equipment perfectly cooperate between conveying and sorting, and achieve the effect of accurate and rapid sorting.

3.2.3 Data processing system

Through multi-layer and various sensors to collect the item characteristic information database, the database is used to receive and send from the single chip microcomputer control system, and the traditional relational databases MySQL and Oracle are used to store each piece of information data. Then, the data from the front-end is imported into a distributed database, and some simple sampling and preprocessing work is done on the basis of the import. Distributed database is used to analyze, classify and summarize the massive data stored in it, so as to meet most common analysis needs. Then, calculations based on various algorithms are carried out on the existing data, so as to achieve the prediction effect and realize some high-level data analysis needs. In the conveying system based on avr MEGA2560, the design scheme of data acquisition and storage of related data in the sorting process is adopted by double storage structure. In this process, the speed and capacity of data storage are different. The scheme is simple, the interface occupies less, and the cost is low. After experiments, the effect is good, and it meets the requirements of design skills.

4 Product innovation points

(1) The conveyor belt operation system adopts the method of multi-rod side-by-side connection, which ensures the stability of the entire conveyor belt operation and the safety of articles on the premise of lightweight.

(2) Unique two-dimensional code design. When designing the sorting technology system of two-dimensional code, because the two-dimensional code has the characteristics of large information storage, the sorting number can be added to the two-dimensional code, and the sorting number can be set as the information of the book.

(3) The transportation platform composed of the lifting system is controlled by the electronic control system, and the two screw motors rotate to drive the platform to move up and down. The separation of the stage and the sorting stage ensures the continuity of book loading and meets the work needs.

(4) Collect the item characteristic information database through multi-layer sensors, use the database to receive from the single chip microcomputer control system, and use the traditional relational databases MySQL and Oracle to store each piece of information data.

(4) Modularization of the fuselage. The software and hardware systems of the intelligent book sorting system adopt modular design, and adopt the mode of identification, collection, transmission and sorting, which ensures the efficiency of sorting and cost control.

(5) High sorting efficiency. The scanning device combines the characteristics of books with other objects such as two-dimensional codes to realize targeted sorting of one product and one code to ensure the accuracy of book sorting; Through experiments and a large number of calculations, the equipment perfectly cooperates between conveying and sorting to achieve the effect of accurate and fast sorting; The intelligent sorting system can store data when it is working, and the two-dimensional code recognition device collects data and stores it in the system, so as to realize rapid statistics on the number and types of books.

(6) Ingenious mechanical structure. In view of the prominent book destruction problem in the field of book sorting at present, this product uses a mechanical gripper with high sensitivity, strong fit and all-round rotation. The front gripper can be completely fitted to the book to ensure the accuracy of sorting. At the same time, the book damage rate is minimized.

This work aims to provide a fully automatic and intelligent book sorting system. The advantage of intelligent book sorting system is that it can sort books continuously and in large quantities, and is not limited by time, human physical strength and other factors, so as to meet the needs of teachers and students for returning books to the maximum extent. Image recognition technology is adopted, which is highly integrated and automated, which can reduce sorting costs and breakage rates and improve sorting efficiency. In terms of overall structure, it consists of three systems: mechanical execution system, image acquisition system and data processing system. The mechanical transfer and sorting system constitutes the hardware part of the equipment. The sorting system includes a conveyor belt and a plurality of universal multifunctional grippers for grasping books; An image acquisition system that acquires the information of the articles carried on the conveyor belt and the first identification number of the tray where the articles are located, and then returns the information to the control system after acquisition; The data processing system receives the article information collected by the image acquisition module and the part of the first identification number, and controls and realizes the mechanical action. The data processing system is the core of the whole work, and the placement, sorting and grabbing of books are completely completed by the processing system. The intelligent book sorting system is of great significance to solve the problems of complicated book sorting process and large consumption of human resources.