The Design of Book Sorter Base on Radio Frequency Identification

Yanbo Niu, Luhao Fang, Songsong Sun, Junhao Jiang, Peijiang Chen

School of Mechanical and Vehicle Engineering, Linyi University, Linyi, 276000, China

Abstract: The efficiency of book borrow in the library has an influence on the result of students' study. In order to improve the efficiency of book borrow, an automatic device is designed for simulating book classification. The book sorter based on RFID and single chip microcomputer controlling system can control directly current motor driving conveyor belt, identifying the electronic tag within the book by the RFID and single chip Microcomputer, and send books to the corresponding recycling box. The practical operation shows that the device has the characteristics of fast reaction and high accuracy for the processing of book number and the equipment control.

Keywords: Book classification; Single chip Microcomputer; RFID; Electronic tag

INTRODUCTION

The book is the essence of the library and it is significant to manage books. Because of the large number of students in school and the large demand for books, it is a difficult and time-consuming job for the managers to put the books returned by the students in place. At present, many libraries identify books with RFID or bar code. But bar code has only very small information capacity, which is the main defect of bar codes. In the place without a database and a convenient network, the use of bar codes is greatly restricted. But the bar code is simpler in structure and lower in cost compared with RFID. Nowadays, many school libraries mainly deal with the books that have been returned by students with three methods: ①By the self-consciousness of the student, the book is placed in the collection box. ②The students put the books in the recycling box after they are returned to the machine at the self-service machine, then these books are sent to the collection rooms of all levels by the workers or volunteers. ③The book is categorized by the teacher directly after the books are returned in the service counter. The book sorter can classify books that have a close distance between them into one category. Using automatic machinery to sort books can save time for arranging books and improve the efficiency of book borrow. After books are classified, workers of library need just to put books back in place.

The classification principle of the device: The RFID can obtain the code of electronic tag in book and could send it to the single chip Microcomputer with SPI communication. The single chip Microcomputer control the operation of motor after identifying the code, then putting the books back in place. The basic structure of the device is composed of three layers of conveyer belt. The uppermost conveyor belt is for the placement of the book. Firstly, RFID scan books. Secondly, the single chip

Microcomputer located in the middle position control the operation of motor by motor drive board. Finally, conveyor belt sent the book to the appointed position.

Overall structure diagram

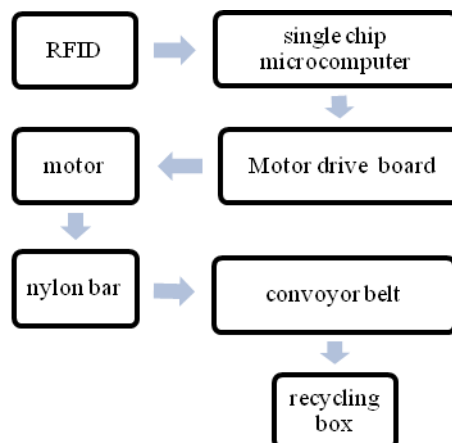The overall structure diagram is given, as shown in Figure 1.

Figure 1. Overall structure diagram

SINGLE CHIP MICROCOMPUTER AND SPI COMMUNICATION

STC89C52

At present, the main types of single chip Microcomputer are MCS-51 series, AT89C5X series, PIC series, AVR series and embedded DSP processor. The STC89C52 microcontroller used in the device, including 8 bit CPU, data memory, program memory, four 8 bit programmable parallel I/O port, two programmable 16 bit timer/counters, a universal asynchronous transceiver serial port, five interrupt sources etc [Zhang, *et. al.*, 2015]. The book sorter mainly uses single chip Microcomputer to simulate SPI port to transmit and receive information with RFID. A timer or counter is used for adjusting and limiting the running time of the machine. The Signal

input to the motor drive board can control the positive and negative rotation of the motor.

The single chip Microcomputer used in the device is given, as shown in Figure 2

Figure 2. Single chip Microcomputer

Analog SPI communication

SPI is a full duplex high speed synchronous serial peripheral interface. Its speed of data transmission is faster than speed of Inter-Integrated Circuit bus, and it can reach several Mbps [Hong, *et. al.*, 2008]. The way it works is master-slave. In other words, the main device and slave device. Generally, it needs four connection lines. If only one way is transmitted, three lines can also achieve data transmission. Including SDI main device data input and accessory device data output, SDO main device data output, and accessory device data input, （SCLK) clock signal and (CS) chip select. There is a disadvantage of the SPI interface: it unable to confirm whether the data is received.

MOTOR DRIVE BOARD

Currently, the mainstream motor driver boards have TB6612FNG, L298N, L293D and other types on the market. Considering the speed and power of the motor, the device selects L298N with a dual H bridge DC motor drive chip. Power supply range: +5V~+35V. Peak current of driving part is 2A. The work currents of logical part range from 0mA to 36mA. The maximum power is 20W. After connecting the electrical source and the signal from single chip Microcomputer, PWM signal input from IN1、IN2 can control the steering and speed of motor1. PWM signal input from IN3, IN4 can control the steering and speed of the motor2. When the enabling signal is 0, the motor is in free stop state. When the enabling signal is 1, and the IN1 and IN2 are 00 or 11, the motor is in the braking state to prevent the motor from turning.

RADIO FREQUENCY IDENTIFICATION

Radio Frequency Identification is a non-contact automatic recognition technology, which consists of three parts of the electronic tag, reader and data exchange and management system [Shen, 2012]. It automatically identifies target objects and gets related data through radio frequency signals. (1) electronic tag. It is the transmitter that carries the data, located in the surface or interior of the target objects. It is usually made up of a coil (or a microwave antenna) and an electronic chip. (2) reader-writer. It is a reader that can read the data from the electronic tag and write the data to the electronic tag [Zhao, 2008].

Working principle of RFID

When an object equipped with a passive electronic tag is close to the reader at a valid distance, the reader send out microwave query signal；After the tag installed on the surface of the object receives the query signal of the reader, tag will combine this signal and data information inside it to a whole and reflect to the tag reader. The synthetic signal carries the data information of electronic tag. After reader receiving the synthetic signal reflected by the electronic tag, the reader can separate and attain the information stored in the tag, such as the identification code, through processed by the microprocessor inside the reader.

The working current of RC522 used in the device is 13-26mA, and the peak current is no more than 30mA, which supports mifare1 S50, mifare1 S70, mifare Ulterlight, mifare Desfire and other card types. MF RC522 utilizes the advanced modulation and demodulation concepts to fully integrate all types of passive non-contact communication modes and protocols with a frequency below 13.56MHz. RC522 support multi-layer applications in ISO14443A. The communication between RC522 and the host computer adopt serial communication using less wiring. It has three power saving modes, such as hardware power down, software power down and power transmission and supports ISO/IEC 14443 Type A and MIFARE® protocol. The chip is connected to single chip Microcomputer through SPI communication.

The definition of the SPI pin is as follows:
sbit CS=P1^0;
sbit SCK=P1^1;
sbit MOSI=P1^2;
sbit MISO=P1^3;

During the operation of the equipment, the main working process of RC522 is to find card, prevent conflict and choose card. After the card selection process is over, control system accomplishes the recognition for electronic tag and returns the number of it.

ELECTRONIC TAG

The tag can be divided into active tag and passive tag according to the power supply mode of the electronic tag.

There is battery inside the active tag which can provide power. Their working distance is far away. They can reach dozens of meters or even hundreds of meters, but their life is limited and the cost is relatively high. There don't have battery inside the passive tag. Passive tag use electromagnetic energy launched by coupled reader-writer for themselves.

Passive tags have a close range of action, but they have a light weight, small volume, long life and low cost. What the device uses is the passive electronic tag.

The electronic chip used in this paper is S50. It has a storage capacity of 8 Kbit, 16 partitions, and two groups of passwords per partition. The frequency for work: 13.56MHz. Effective distance of reading and writing: 2.5~10cm. The time about reading and writing: 1~2ms. Working temperature: -20℃~ 85℃. The S50 electronic tag has the following advantages:
(1) High reliability. It avoids a lot of trouble caused by dust and greasy dirt because there haven't mechanical contact between the non-contact chip and reader.
(2) Easy operation. Its work speed was improved because the chip is non-contact communication.
(3) Conflict prevention. There is a fast conflict prevention mechanism inside the non - contactless chip, which can prevent the data interference between chips.

LCD12864 Liquid crystal display screen could gain the coded message of electronic tag which is equivalent to call numbers of books.

Visualizations of electronic tag

LCD: liquid crystal display screen. The display screen matching with the microcontroller is mainly LCD1602, LCD12864 and so on. What device uses is the LCD12864 display screen because of the advantages of large screen, clear information display and large amount of information processing. It displays the information got by scanning, when LCD12864 is connected to RFID, which is mainly encoded information inside the electronic tags. LCD12864 is composed of a display screen, a controller, a driver and a bias voltage generation circuit. The working current is 1.2mA (5V). The working temperature: -20℃~70℃. This module is equivalent to an external device of the system, connected to the system bus directly, and receives commands and data from the microcontroller through the port [Chen, *et. al.*, 2007].

PRODUCTION PROCESS

The book sorter mainly uses the following materials: RFID, Single chip Microcomputer, 370 motor, 12V battery, thin conveyor belt, Nylon bar, Angle aluminum, Bearing, Couplings, Sandpaper, Silica gel line, DuPont line, Mobile power and Motor drive board.

The hardware structure of the equipment is multi-layer design, and the books are transported to every recycling box through the layered movement of books. Angle aluminum is a support for the whole. The bearing fixed on the frame is used for supporting nylon bars that can tighten the conveyor belt. The sandpaper could increases the friction between the nylon bars and the conveyor belt as well as ensuring smooth transportation. The system takes single chip as

the core, combining LCD and RFID, controls the whole device and monitor it [Ma, *et. al.*, 2012]. There is a silica gel line between the motor and the mobile power. The link between the single chip Microcomputer and the RFID chip and the motor drive board is connected with DuPont line.

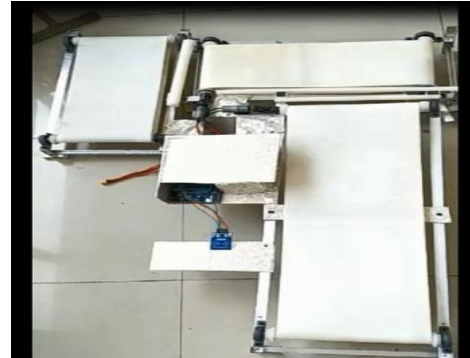The appearance of the device is given, as shown in Figure 3.

Figure 3. The actual picture of the device

Use procedure: Touching the book on the RFID, the single chip Microcomputer receives the corresponding signal when RFID induces the book meanwhile the program operates. The motor starts to run in different positions according to the predetermined direction. The books will move along the conveyor belt to the corresponding recovery box. With the spring of the bottom of the box, books are well placed at the highest level. Books in the recovery box are directly sent to the corresponding bookshelves.

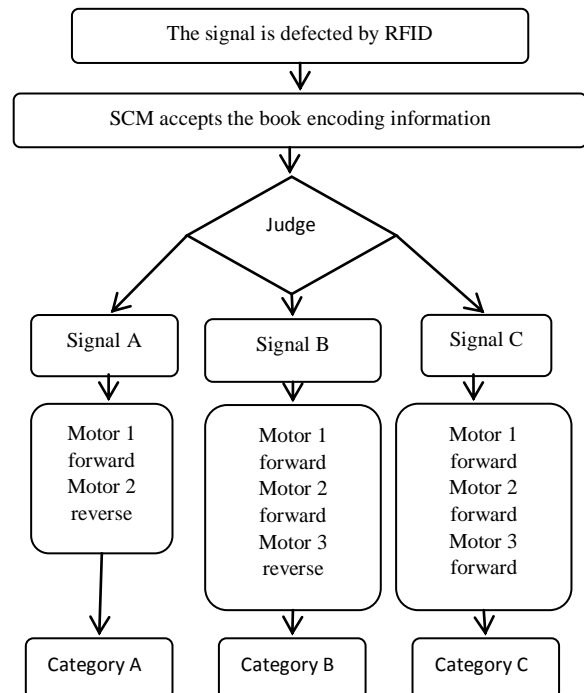The working flow chart is given, as shown in Figure 4.

Figure 4. Working flow chart

CONCLUSIONS

The book sorter could recognize the coding of books and classify books according to the deposit location of books, which could reduce the segment of book returning and the labor intensity of staff. Meanwhile, it also can solve the problem that books are returned to the library but can't be borrowed. But the size of the conveyor belt is larger in a way and the security and stability of the self-service system still have room to improve. It takes about 5.5 seconds to return books by this equipment, which is more efficient than artificial screening.

At present, the university libraries recognize books by RFID or bar code. Using RFID to manage books improves the information capacity of book and gives the reader a better understanding about books. Therefore, library can provides better and more efficient services for students.

REFERENCES

L. Hong, P. Yan, R.D. Yi, 2008, "embedded system extension method based on SPI and MCU ", Microcomputer Applications, 2008, (24), pp. 21~23.

L.L. Ma, X. Gao, C.X He, J.W. Ji, 2012, "The hardware design of temperature detection system based on single chip microcomputer", Modern Instrument, 2012, (18) , pp. 60~61.

J.H. Zhao, 2008, "radio frequency identification technology and application", China Machine Press, (2008).

X.C Chen, C.Q. Geng, 2007, "LCD terminal design based on single chip Microcomputer", Electric Power Automation Equipment, 2007, (27) , pp. 110~112.

Y.G. Zhang, Y. Yu, D. Liu, L.B. Deng, "microcontroller principle and application design: C51 programming + Proteus simulation", Publishing House of Electronics Industry, (2015) .

Y.P. Shen, "Pet management based on RFID", China Qinghai Journal of Animal and Veterinary Sciences, 2012, (42), pp. 43~44.