A design of self-learning intelligent infrared remote controller

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Abstract. This paper presents a self-learning intelligent infrared remote control system for Android system. In this paper, STM32F103RCT6 chip is selected as microprocessor, infrared integrated receiver head VS1838 and infrared light emitting diode are used as infrared receiving/transmitting module. The communication of experimental platform system is established to realize the management and control of household appliances by mobile terminal.

1. Introduction
Infrared remote control has the advantages of low cost, low power consumption, stable performance and powerful function, which has been widely used in the field of home appliances. When the number of household appliances increases gradually, the corresponding remote controls also become more and more, and it will cost a lot of time to find the corresponding remote controller. At the same time, with the rapid development of mobile terminals, mobile phones become an important part of people's life, people hope to use only mobile phones to control household appliances.

2. Overall design of infrared intelligent control system
In order to solve the communication problem between household appliances and make it more convenient and free for users to control household appliances, this paper proposes a self-learning intelligent infrared remote control system[1-2], which is composed of microcontroller, WiFi module, infrared receiving/sending module, storage module, etc. The system can not only decode, compress and store the infrared remote control signals of different remote controllers, but also receive control commands from mobile phones to control household appliances. Through the self-learning infrared remote control system, users can operate household appliances more simply and effectively, and the system can also participate in the control system of smart home as a subsystem to promote the development of smart home. In terms of function, the intelligent infrared remote control system has the following features[3-6], such as the capability of infrared decoding, signal storage, communication and infrared coding.

According to the design purpose, functional characteristics and overall idea of the infrared control system, combined with their own knowledge and laboratory equipment conditions, the hardware circuit design of the microcontroller and each functional module is completed, as shown in figure 1 below. The self-learning infrared remote control system is mainly composed of microcontroller, infrared receiving/transmitting module, WiFi module, storage module and so on.
3. Hardware design of self-learning intelligent infrared control system

The self-learning intelligent infrared remote control system is mainly composed of microcontroller, WiFi module, infrared receiving/sending module and storage module. The whole system is controlled by microcontroller. The household appliances and mobile devices are networked to realize the integrated integration of electrical appliances and networks. The wireless remote control command of mobile devices can send control commands at any time to realize the effect of remote control of household appliances.

The self-learning intelligent infrared remote control system designed in this experiment has the function of learning and sending infrared remote control signal. The receiving and sending of infrared remote control signal determines the success or failure of the whole system. In order to protect the infrared remote control signal from other noises, the infrared signal is usually modulated and demodulated. When receiving the signal, the signal is demodulated in a specific carrier frequency band to filter out the interference wave except the normal infrared signal, and only receive the infrared signal in accordance with the specific frequency. When transmitting, the signal is modulated to a specific carrier frequency band and transmitted through the infrared transmitting circuit.

The hardware circuit design of the system mainly includes the main chip selection design, storage chip selection design, infrared receiving/transmitting circuit design, serial port debugging circuit design and so on. The actual system diagram is shown in figure 2.

3.1. Main chip selection

STM32F103RCT6 is selected as the main control chip in this system. Its clock frequency is 8MHz, and it is highly integrated with flash and SRAM memory. Its program storage capacity is 256kB and RAM capacity is 48k. It is equipped with 32-bit RISC processor of arm Cortex-M3, so the code execution efficiency is higher. It has a USART serial port and 64 general I/O interfaces. Users can reuse their functions according to their actual situation, which can fully meet the functional requirements of this experiment. STM32 microcontroller is shown in figure 3.
3.2. Design of infrared receiving circuit

The infrared receiving circuit of this experimental system is composed of low noise amplifier, limiter, band-pass filter and so on. Combined with the current receiving module in the market, considering the chip size, sensitivity, cost, anti-interference ability and other aspects, the integrated infrared receiver vs1838 with reliable performance is selected. The module contains high sensitivity PIN photodiode and high gain integrated amplifier circuit, and has anti-interference design. It is easy to use and has strong portability. When the system receives the infrared remote control signal, it will be amplified, detected and demodulated to a specific frequency. The technical parameters of vs1838 are shown in table 1.

When the system is in the learning state, the microcontroller reads the signal of the integrated infrared receiving head through the serial port, decodes the signal by measuring the high and low level time of the data, determines whether the transmitted data is "0", "1", guide code or connection code, and then checks whether the length of the data and the guide code are correct. When the infrared signal is correct, the signal is decoded and stored. The infrared receiving circuit is shown in figure 4.

| parameter                  | Symbol | Test conditions | minimum value | Typical value | Maximum | Company |
|----------------------------|--------|-----------------|---------------|---------------|---------|---------|
| working voltage            | Vcc    |                 | 2.7           | 5.5           | V       |        |
| Working current            | Icc    | VDD=5V          | 0.6           | 1.0           | MA      |        |
| Quiescent current          | Ic     |                 | 0.5           | 0.5           | MA      |        |
| Receiving distance         | L      | No signal input | 11            | 13            | M       |        |
| Receiving angle            | 01/2   | EV = 200 ± 50Lux| ±35           |               |         | Deg     |

3.3. Design of infrared transmitting circuit

Infrared emitting tube is a kind of special diode, which can convert electric energy into infrared light and radiate it. At present, it is widely used in remote control transmitting circuit and photoelectric switch circuit. The forward bias voltage of the infrared emitting tube injects current into the PN junction (which is made of high infrared radiation efficiency materials such as gallium arsenide) to make the LED emit infrared light with the wavelength of 830-950nm.

The infrared emitting tube has electrical, directional and distance characteristics. When the ambient temperature is higher, the direction angle is smaller and the infrared distance is shorter, the reliability of infrared diode is better. The infrared transmitting circuit is shown in figure 5.

When the microcontroller receives the infrared control command from the mobile handheld device, the system first generates a carrier frequency of 38kHz, and then encodes the infrared remote control signal stored in the system and modulates it to the carrier frequency to form a pulse wave. These pulse waves are amplified by triode and then emitted by infrared diode to control household appliances.

![Figure 4. Infrared receiving circuit.](image1)

![Figure 5. Infrared transmitting circuit.](image2)
3.4. Design of memory chip
Micro SD card is mainly used in mobile phones. It is a kind of flash memory card with small volume and huge storage capacity. It is based on flash and can be erased many times. Using SPI standard protocol, it is easy to operate, small size, fast speed and large capacity.

Due to the limited storage capacity of the microprocessor, it can not meet the decoding and storage function of infrared signals from different buttons of the infrared remote controller. Therefore, the design scheme of external storage chip is adopted in this experiment. Based on the wide use of mobile phone memory card, this design combined with the conditions of the laboratory, selected the storage capacity of 1GB micro SD card to store the infrared remote control signal. According to the programming principle of STM32, SPI bus interface is used to communicate with STM32, which effectively expands the memory performance of the chip and enriches the functions of the system. The SD card holder is shown in figure 6.

3.5. Serial debugging interface
In the process of system debugging, it is necessary to observe the status of the system in real time and view the received data. In this experiment, the USB to serial module is used as the communication interface, and the signals received and transmitted by the whole system can be easily observed by using the serial debugging assistant on the computer. The module supports hot plug, plug and play, and the transmission speed is fast, which is convenient for experiment. The USB to serial port module is shown in figure 7.

The serial debugging assistant used in this experiment can automatically identify the serial port, support 9600, 115200, 38400 and other common baud rates and user-defined baud rates. It can set data bits, check bits and stop bits. It can receive and send data in binary or hexadecimal mode. It can save the received information as a text file, and can also send text files.

![Figure 6. SD card holder in SPI mode.](image1)
![Figure 7. USB to serial port module.](image2)

4. Example design of control object
The infrared remote control signal of traditional household appliances is generally composed of 32-bit binary pulse code, and the complete infrared remote control signal generally includes guide code, data code, connection code and check code. In this paper, the existing Gree air conditioner is taken as the experimental object for learning and controlling. The infrared remote control signal of the remote controller (ya0pf2) of Gree air conditioner can be obtained by using oscilloscope test, as shown in figure 8 and figure 9.
When the scanning period is reduced, the signal can be expanded, and the remote control signal is composed of two sections. The composition format of each control code is as follows:

Starting code (s) + 35 bit data code + connection code (c) + 32 bit data code

In addition, we also found that the infrared remote control signal uses NEC protocol and PPM encoding format. The level width of each data is as follows:

Logic 0: 600us low level + 600us high level
Logic 1: 600us low level + 1600us high level
Start code s: 9000us low level + 4500us high level
Connection code C: 600us low level + 20000us high level
Connection code L: 600us low level + 40000 US high level

For example, when the refrigeration temperature is 22 degrees, the wind is low, and the left and right upper and lower sweeps are closed, the remote control signal is:

68100110000110000000000000000101001040000000000000010000000000000110158100110001000110000000000000000001100104000000000000001100104000000000000001100104000000000000001100104000000000000001

(where: 6 is the flag bit, 8 is the start code, 4 is the short connection code, and 5 is the long connection code)

The control signals of the first segment of infrared coding are shown in the table below.

(1) The formation of the first 35 bit data code is shown in table 2.
Table 2. The first 32 bits data code of Gree air conditioner remote control.

| Mode switch | switch | wind speed | Sweep the wind | sleep | Temperature data | Timing data |
|-------------|--------|------------|----------------|-------|-----------------|-------------|
| 21          | 22     | 23         | 24             | 25    | 26              | 26–35       |

Super strong lighting healthy dry Ventilation 0001010010

(2) The form of the last 32-bit data code is shown in table 3.

Table 3. Rear 35 digit data code of Gree air conditioner remote control.

| mode | wind speed | Temperature display |
|------|------------|---------------------|
| 00   | 000        | 0001000000000000    |

Blowing up and down Left and right sweeps 19–32

energy conservation Check code

(3) The mode symbol, wind speed and temperature of data bits are shown in table 4, table 5 and table 6 respectively.

Table 4. Mode flag data of Gree air conditioner remote control.

| Pattern flag | automatic | refrigeration | humidification | Air supply | heating |
|--------------|-----------|---------------|----------------|------------|---------|
| 00           | 100       | 010           | 110            | 001        |

Table 5. Wind speed sign bit data of Gree air conditioner remote control.

| Wind speed sign | automatic | class a | second level | Three levels |
|-----------------|-----------|---------|--------------|--------------|
| 00              | 10        | 01      | 11           |

Table 6. Temperature mark bit data of Gree air conditioner remote control.

| Temperature data | 16degree | 17degree | 18-29degree | 30degree |
|------------------|----------|----------|-------------|----------|
| 0000             | 1000     | 01       | 0111        |

(4) The formation mechanism of the check code is as follows: check code = [(MODE-1) + (temperature-16) + 5 + left and right sweeping + ventilation + energy saving]. Take the last four bits of binary, and then reverse the sequence; for example, if you need to set the following state, mode 3, 29 °C, left and right scavenging, ventilation on, energy saving off, then the check code is: (3-1) + (29-16) + 5 + 1 + 1 + 0 = 15, take the lower four bits as 0111, and then reverse the sequence to 1110.

(5) In addition, the functions that can be set in different modes are different, as shown in table 7.

Table 7. Parameter setting of Gree air conditioner remote control in different modes.

| Automatic | Shut down | Refrigeration | Heating | Dehumidification | Air supply |
|-----------|-----------|---------------|---------|------------------|------------|
| Temperature | Sweep the wind | Wind speed | Timing | Sleep | Lighting | Temperature display | Health display | Energy conservation |
| Automatic | √         | √             | √       | √     | √       | √           | √            | √               |
| Shut down  | √         | √             | √       | √     | √       | √           | √            | √               |
| Refrigeration | √       | √             | √       | √     | √       | √           | √            | √               |
| Heating    | √         | √             | √       | √     | √       | √           | √            | √               |
| Dehumidification | √   | √             | √       | √     | √       | √           | √            | √               |
| Air supply | √         | √             | √       | √     | √       | √           | √            | √               |
For the Gree air conditioner remote control owned by the laboratory, the remote control code has occupied 140 bytes, and the storage space required is relatively large. Therefore, after receiving the infrared signal, the remote control code is compressed, and the waveform information is recorded. The waveform information is stored in the memory chip. When the STM32 receives the infrared signal from the incoming mobile phone, it calls the stored data, encodes and modulates it, and then transmits the infrared signal through the infrared transmitter circuit to control the air conditioner.

5. Conclusions
According to the overall design idea of the self-learning intelligent infrared remote control system, this paper focuses on the functional characteristics of the experimental system. Then the hardware design of the system is introduced, which is mainly composed of microcontroller, WiFi module, infrared receiving/transmitting module and storage circuit. The selection and circuit design of each module are introduced in detail, especially the infrared receiving/transmitting module, which needs to realize the learning, storage and transmission functions of infrared remote control signal, and it is the core part of the whole system.

The system combines mobile terminal technology and infrared communication technology, and has the characteristics of low power consumption, small size, powerful function, high reliability and wide control range. In the field of smart home innovation, people have more pursuit of life, the system studied in this paper has broad prospects for development.

Finally, aiming at Gree air conditioner, which is the experimental object of this experiment, the coding mode of infrared remote control signal of the household appliance and the corresponding coding system composition are mainly studied, which provides a great reference value for the realization of the overall function of the system.

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