

Intelligent transformation design of ordinary door lock device based on WIFI communication technology

Piao Liang*, Liangjun Liu, Zhiling Wang, Huajin Luo

Institute of Electronic Engineering and Intelligence, Guangxi Vocational Institute of Technology,
Chongzuo 532200, Guangxi, China

ABSTRACT

The ordinary door lock device based on WIFI communication technology mainly uses the technical fusion of WIFI communication technology, Bluetooth technology and fingerprint recognition to realize the intelligent transformation of the ordinary door lock device without replacing the lock body. The main control of the system is the STM32 microcontroller, which authenticates the identity information of the householder through the WIFI communication module, Bluetooth communication module, or fingerprint recognition module; The WIFI communication module is connected to the wireless router at home so that the user can connect with the system through terminal devices such as mobile phones, so as to complete the information authentication; After the information authentication of the head of household is successful, the STM32 main control chip pulls the doorknob lock on the inside of the door through the motor, so as to realize the keyless unlocking function, complete the intelligent transformation of ordinary door locks, and allow users to experience the remote control and convenient unlocking of smart locks in the new era without replacing the original lock body, enriching and improving people's quality of life.

Keywords: WIFI communication, keyless door locks, fingerprint unlocking, phone unlocking, STM32

1. INTRODUCTION

Locks have a long history and were born almost at the same time as private ownership. According to the research of unearthed cultural relics and historical documents, the development of locks has a history of 5,000 years^{1,2}. With the continuous progress of science and technology, door locks have gradually become intelligent. The existing smart door locks have various types such as face recognition, fingerprint recognition, and wireless sensing, and users can unlock them through various channels such as face recognition, fingerprint recognition, or network remote password³. The lock body structure and door opening method of the smart door lock are different from the traditional lock body, and the control panel cannot directly control the original lock body, usually, the original lock body must be removed first, and then the lock body matched with the smart door lock control panel is installed. This not only has a high cost of transformation but also causes a waste of resources by discarding the original lock body. If a door opening device is installed on the original door lock, it is used to authenticate the user's identity information by integrating WIFI communication technology, Bluetooth technology fingerprint recognition technology, and other related technologies, and when the identity information is confirmed, the door lock is unlocked and opened through the door opening device, which not only greatly reduces the transformation cost of the intelligent control of the door lock, but also does not need to discard the original door lock to cause waste of resources, which is just in line with the consumption concept and value orientation of most ordinary consumption level families. Below is the detailed design of the system.

2. SYSTEM DESIGN

The design is mainly composed of a user identification system, an Internet, a signal processing system, an execution system, and a terminal device, and its design drawing is shown in Figure 1. The user identification system includes WIFI communication, Bluetooth, and a fingerprint recognition module, and the user can unlock the fingerprint through fingerprint, or connect the Bluetooth module or WIFI module of the system through the mobile phone APP, and unlock the mobile phone through the specified communication protocol. At the same time, the WIFI module is also connected to the Internet through the indoor router, and the user can also use the terminal device to establish a connection with the

*2200434372@qq.com

system through the network with the specified communication protocol, so as to realize remote password unlocking and the unlocking methods are diverse. The system is a lightweight network protocol based on the MQTT protocol, which can effectively reduce network latency and speed up information exchange³⁻⁵. The actuation system is composed of a motor and a gear device, the gear device is connected to the end of the handle in the door through the wire rope when the door needs to be unlocked and opened, the main control system controls the motor to run, and the gear device pulls the door handle because of the wire rope to reach the purpose of unlocking the door opening.

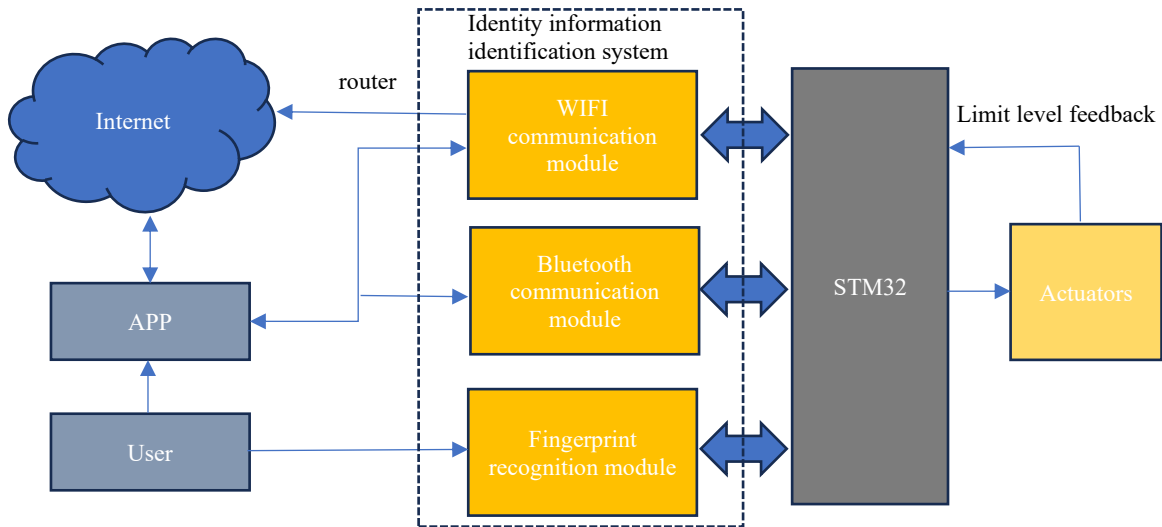


Figure 1. System design diagram.

3. ACTUATOR DESIGN

The actuator is installed on the inside of the door, mainly used to pull the inner door handle to perform the action of unlocking and opening the door, and is mainly composed of components such as motors, gear devices, and wire ropes. One end of the wire rope is fixed on the output shaft of the gear unit, and the other end is fixed at the end of the inner door handle. When it is necessary to carry out the action of unlocking and opening the door, the motor transfer drives the gear device to rotate, and the output shaft of the gear device winds up the wire rope to pull the inner door handle, so as to achieve the purpose of unlocking and opening the door, and its structural schematic diagram is shown in Figure 2.

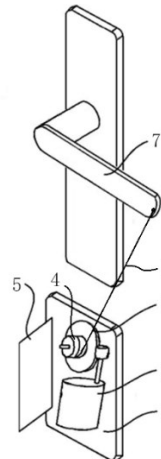


Figure 2. Schematic diagram of the structure of the actuator.

Note: 1-base, 2-motor, 3-gear device, 4-gear unit output shaft, 5-control circuit module, 6-wire rope, 7-inner door handle.

4. HARDWARE DESIGN

The system hardware circuit is mainly composed of a single-chip microcomputer main control chip, a motor drive circuit, and an identity information recognition module and other circuits, wherein, the identity information recognition module comprises a WIFI communication module, a Bluetooth communication module and a fingerprint recognition module, and its circuit connection schematic diagram is shown in Figure 3.

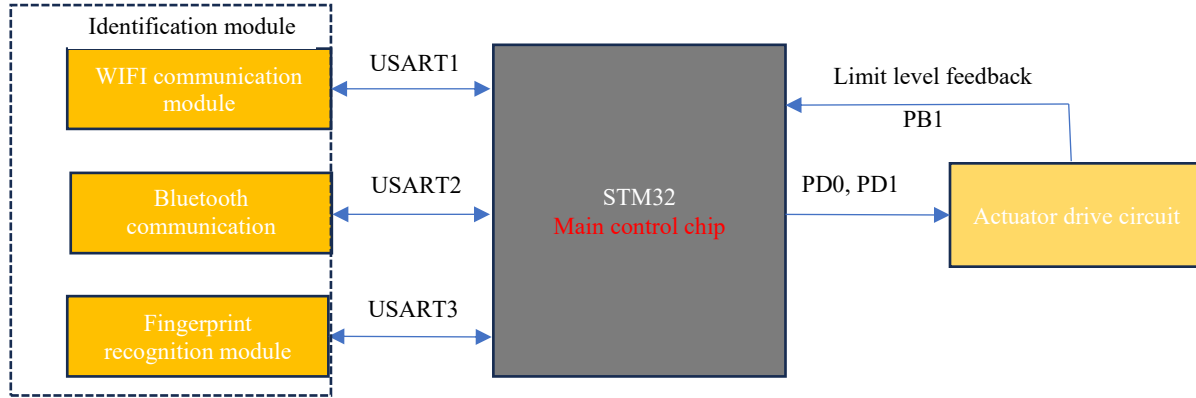


Figure 3. Schematic diagram of circuit connection.

The system adopts an STM32 series single-chip microcomputer as the main control chip, and its port serial port 1 (USART1) is connected to the WIFI communication module, serial port 2 (USART2) is connected with Bluetooth module, and serial port 3 (USART3) is connected with fingerprint recognition module; The PB1 pin is connected to the limit sensor of the actuator and is used to read whether the actuator is executed in place; The PD0 and PD1 pins are connected to the actuator's drive circuit, and the drive circuit controls the motor operation by outputting a PWM signal.

The actuator drive circuit is an integrated chip with an internal H-bridge circuit, as shown in Figure 4. The main control chip controls the two inputs of the driver chip through the PD0 and PD1 pins respectively to rotate or reverse the motor, so as to realize the execution of unlocking the door opening or the reset of the door lock handle.

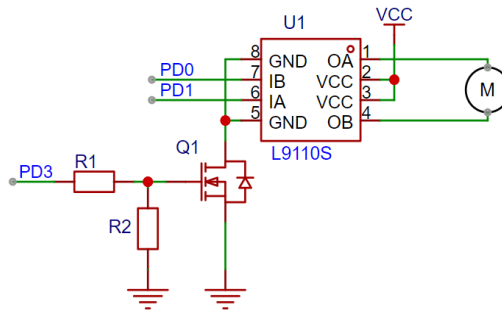


Figure 4. Actuator drive circuit diagram.

In order to further reduce the power consumption of the device, a field effect transistor Q1 is used to control the power supply that executes the drive circuit. When the user's mobile phone is successfully connected with the system, the MOSFET Q1 works, and the actuator driving circuit is energized and waits for the unlocking action to be executed; When the execution ends for more than a certain period of time or the user's mobile phone is disconnected from the system, the field-effect tube Q1 is cut off, and the actuator drive circuit loses power and enters the ultra-low power mode.

5. WIFI COMMUNICATION AND ACTUATOR CONTROL PROGRAM

The system is connected to the Internet through the WIFI module, and the user terminal equipment can communicate with the system in both directions through the Internet. The system master uses the MQTT protocol, which is a lightweight, publish-subscribe-based messaging protocol that is applicable to TCP/IP protocols⁶⁻⁹. After the user terminal establishes contact with the system, according to the MQTT protocol, the main controller encapsulates information such as door lock status and connection mode into data packets and sends them to the WIFI module through serial port 1. The WIFI module

forwards the message to the indoor router to realize the function of connecting the system to the Internet. At this time, the user can use the IoT cloud platform as the medium on the mobile terminal to send a control data message to the physical hardware with the specified communication protocol, and the main control chip can extract the control signal through decoding after receiving the data message, so as to achieve the purpose of remote unlocking of the hardware control. The main program flow diagram of the main control chip is shown in Figure 5.

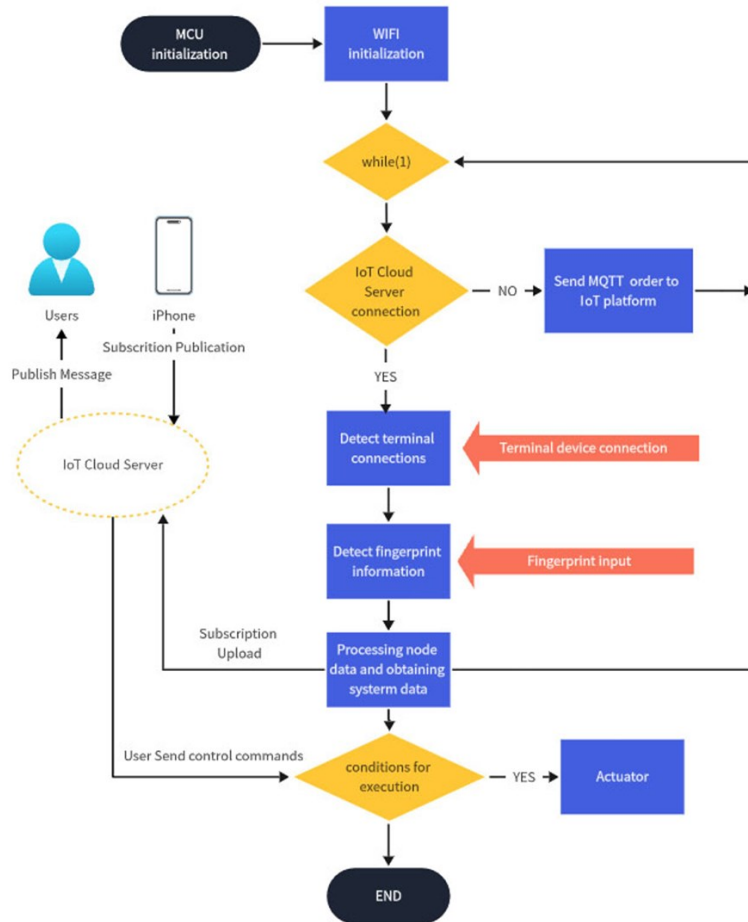


Figure 5. Flow chart of the main program of the main control chip.

6. SYSTEM TESTING

In order to facilitate the user to operate the system through the mobile terminal and realize the intelligent unlocking function of the door lock, a specific APP control software has been developed through E4A software. The APP software has a main window and four sub-windows, the main window is the unlocking control interface, which provides three connection modes: WIFI connection, Bluetooth connection, and Internet cloud connection. When using it for the first time, you can choose a WIFI connection or Bluetooth connection to initialize the system settings to record the owner's information. When the Bluetooth mode is selected, click the "Turn on Bluetooth", "Start Search", and "Connection" button labels in turn, enter the initial password of the system in the pop-up password input box, and click the "OK" tab to enter the system, at this time, the system will pop up the prompt box that highlights the "Please enter the main information of the household for the first time", enter the administrator's fingerprint, ordinary user fingerprint, modify the administrator's password and ordinary user password and other information according to the guidance, and then click the WIFI connection information interface. Enter the name and password of the router WIFI hotspot respectively, click the "Complete" tab, and the system will automatically connect to the router hotspot through the WIFI module (the above operation only needs to be operated once, when the system configuration is completed, the next time the system is started, the WIFI module will automatically connect to the router hotspot). When the system is successfully connected to the router, the system transmits the relevant

information such as the status of the door lock to the IoT cloud platform, and the user's mobile terminal will pop up a prompt label of "the system is connected", and the user can remotely unlock the door lock and open the door through the Internet^{10,11}.

In the system authentication mode, the user presses his finger on the fingerprint recognition module, fingerprint recognition module reads the user's fingerprint information and compares it with the information entered in the system, when the fingerprint information matches the information in the system, the main control chip controls the actuator action to complete the unlocking and opening function. The system installation effect and APP interface are shown in Figure 6.

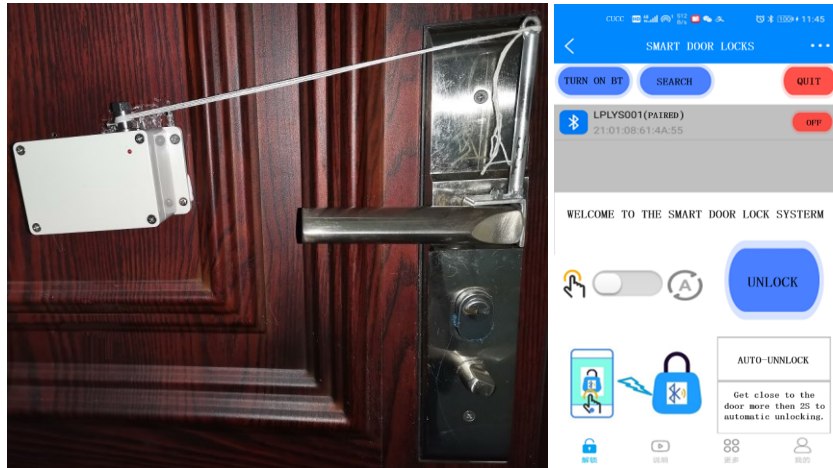


Figure 6. System installation effect and APP interface.

7. CONCLUSION

The system uses STM32 as the main control chip, and without replacing the original door lock body, a door handle door opening actuator is installed on the inside of the door, and the door opening function is unlocked by controlling the action of the actuator. In order to realize the intelligent control of the door lock, the system integrates WIFI communication technology, Bluetooth technology, and fingerprint recognition technology to authenticate the user's identity. At the same time, the WIFI communication module is used to make the system connect to the network through the indoor router and upload the relevant information such as the status of the door lock to the Internet of Things cloud, and the user can monitor the status of the door lock in real-time through the mobile terminal, and carry out remote control. It can be seen that the system not only has the keyless unlocking function of the modern smart lock, but also because there is no need to replace the original lock body, the intelligent transformation cost of the system is lower, and the elderly who will not use modern technology to unlock can still use the original mechanical key to unlock the door, and the practicability is greater.

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