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Design and Development of Intelligent Access Control System Integrating Hi3861 and K210

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Abstract: Based on the face recognition access control function, a fully localized hardware system has been developed. The system takes Huawei Hi3861 main control MCU, Sipeed K210 AI chip of KANAN Technology, FPM383C fingerprint recognition module of Hailinko Electronics, PCF8574 IO module of NXP, and PN532 communication module as the main hardware structure, and Huawei open-source system OpenHarmony is the software system, optimized by deep learning algorithms to achieve safe, efficient and intelligent user access management functions. Experimental results show that the system in a variety of lighting conditions and angle changes, are able to achieve high-precision face recognition, false recognition rate of less than 0.1%, recognition time of less than 200ms, fully meet the needs of practical applications for efficient access and security management.

Keywords: embedded; Internet of Things; artificial intelligence; OpenHarmony; guarded entrance

1. INTRODUCTION

In today's society with the rapid development of artificial intelligence technology, security and convenience have become an important demand of modern life. In the entrance management of residential and office places, most of the traditional mechanical door locks have been replaced by fingerprint door locks because they rely on keys, which are unfavorable for users to carry and keep. Fingerprint door locks can be recognized according to each user's unique fingerprint [1], is a relatively high reliability of the door locks, but due to some physical reasons such as the identification area is humid, dirty with foreign objects and so on and lead to the effective identification of the lack of intelligence, so based on the existing artificial intelligence deep learning technology to develop a kind of integration of advanced face recognition technology, and has a highly efficient processing capacity and reliable security performance of the intelligent door lock system appears to be more convenient [2].

According to the report released by HNYResearch, the global smart lock market size was 1.24 billion U.S. dollars in 2017, and the global smart lock market size will reach 2.61 billion U.S. dollars by 2023, with a compound annual growth rate of 13.26%, while the major smart lock brands researched in the report did not include the major smart lock brands in China. And the domestic data of the National Lock Industry Information Center shows that the national demand for smart locks was 3 million sets in 2016, 8 million sets in 2017, and the demand has reached 14 million sets in 2018, and the output value has exceeded the scale of RMB 10 billion [3]. However, most of the smart door locks on the market are using STM32 series of STMicroelectronics main control chip, network shared resources are also STMicroelectronics, TI, ARM and other foreign mainstream semiconductor manufacturers products [4].

To address the above issues, this paper will select the Hi3861 chip produced by Huawei Hesse as the system master control chip for IoT scheduling [5], and use Sipeed K210 as the algorithmic processor for image processing and face recognition aspects [6]. The aim of this paper is to design and implement a multifunctional and fully localized smart door lock system incorporating Huawei Hi3861 Wi-Fi module and Sipeed K210 microcontroller to meet the market demand for high security and convenient access control solutions. The system utilizes the K210's KPU for local real-time face detection and recognition, and the Hi3861's Wi-Fi function for remote management and data transmission. The results show that the access control system can achieve fast response, high-precision face recognition, and convenient networked management.

2. SYSTEM ANALYSIS

The access control system designed in this paper adopts a master and a slave dual Micro Controller Unit (MCU) design, a master and a slave mode design is conducive to reducing system power consumption and improving operational efficiency. The master MCU selects Huawei Hi3861 chip, which is mainly responsible for task scheduling and data processing, command issuance, and connection to Huawei Cloud, and the slave MCU selects Sipeed K210 AI chip, which is mainly responsible for face recognition-related tasks, including loading face recognition models, face data acquisition and processing. Deploying the face recognition tasks to the Sipeed K210 AI chip can improve the inference speed of the model, thus realizing a highly accurate and sensitive recognition effect of the face, and reducing the Hi3861 computing load to make the scheduling of each task smoother. In addition to the face recognition function, the intelligent access control system adds the functions of key unlocking, fingerprint recognition unlocking, NFC unlocking, and cloud unlocking to make the system more diversified. The block diagram of the hardware structure designed in this study is shown in Figure 1.

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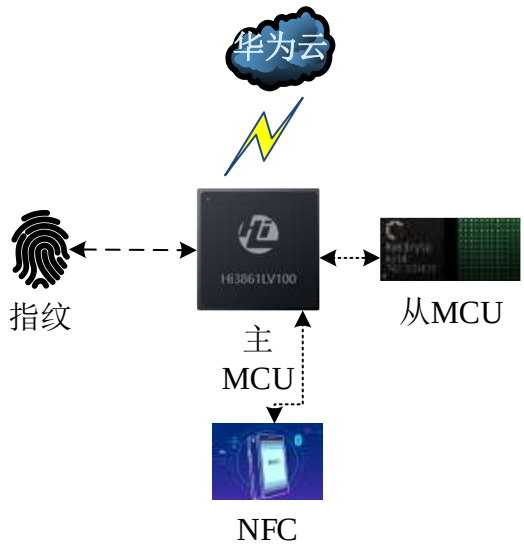

Figure.1 System hardware structure diagram

2.1 Functional Analysis

As a multi-functional intelligent system needs to have the most basic function of the access control system, that is, the lock control function. In the locking form, in order to make the locking form more diversified, locking system more perfect, the system in addition to face recognition function, add key input password locking function, fingerprint recognition locking function, NFC recognition locking function, cloud operation function.

Face recognition opens access control function decomposition: face recognition function, face verification function, data communication function.

Push - button password input unlocking function decomposition: push-button password input function, password setting function, password storage function, password verification function.

Fingerprint recognition unlocking function decomposition: fingerprint entry function, fingerprint deletion function, fingerprint enrollment function, fingerprint recognition function.

NFC recognition unlocking function decomposition: NFC command function, NFC read card recognition function.

Breakdown of the cloud operation function: the function of issuing unlocking commands from the cloud.

2.2 Hardware Circuit Diagram

The system block diagram is shown in Figure 2, which consists of Hi3861 and the relay to form the upper computer, and Hi3861 sends switch commands to the relay to open the door lock; the lower computer consists of MCUK210, IO expansion chip PCF8574, fingerprint module FPM383C, NFC module PN532, which completes the data acquisition and arithmetic processing, and completes the information interaction with Hi3861. information interaction.

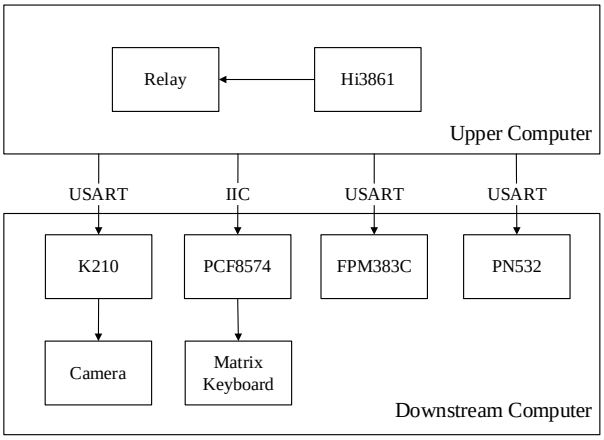

Figure.2 System block diagram

Project master Hi3861 has a total of 15 IO ports, according to the chip manual IO port resources, IO0, IO1 will remain unchanged, assigned a buzzer and fan, IO2 is configured as an output assigned to the state control of the lock, IO3 and IO4 to maintain the original state, set up as a pair of serial pins, IO3 set up as a serial port send pin, IO4 set up as a serial port receive pins, assigned to the on-chip NFC-Tag, which is used for the cell phone to write WIFI password to connect to the network; IO5 and IO6 are multiplexed as the second pair of serial pins, which are used to communicate with K210 for the face recognition task; IO7 and IO8 are kept unchanged; IO9 and IO10 are multiplexed as the clock and data lines of I2C, respectively, which are used for communicating with the PCF8574 module to realize the function of keypad unlocking; IO11 and IO12 are multiplexed as the third pair of serial pins, IO11 is responsible for sending commands to control the FPM383C module, and IO12 is responsible for receiving the signals transmitted by the FPM383C module; IO13 and IO14 are multiplexed as the key functions, which are used for realizing the opening of the face recognition function and realizing the enrollment task in the fingerprint function by pressing the key.PN532 and fingerprint recognition function, switching the I/O through the switch. Usage rights. The physical diagram of the project is shown in Figure 3.

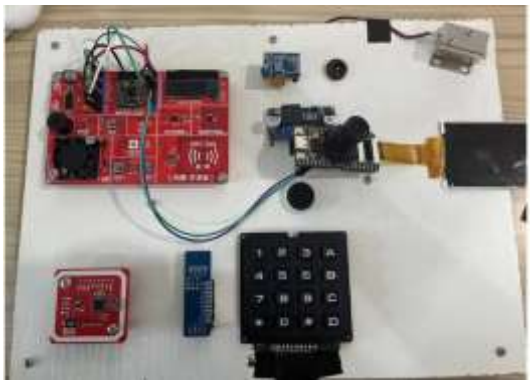

Figure.3 Concrete figure

3. SYSTEM DESIGN

Through the demand demonstration and analysis of the access control system in the previous section, we divide the whole system into seven modules, namely: face recognition module, fingerprint recognition module, key input module, NFC recognition module, Huawei IOT platform connection, OpeHarmony design, and data communication protocol design. Through the connection of each module to complete the design of the entire system, the use of all localized chips to achieve artificial intelligence-based access control system.

3.1 Face Recognition Module Design

In the face recognition module, the KPU is used to realize the face recognition function, and after successful recognition, it passes the unlocking command to the main MCU Hi3861. The flow of the module is as follows: firstly, train the model in the website provided by K210 and convert the model to the format supported by KPU; after the model training and conversion are completed, copy the model to the pre-prepared SD card. In the code flow, first we need to load the model in the SD card, reuse the GPIO port on the K210 as the serial port, turn on the timer function, turn on the LCD display function, and create a file in Flash to store the target features; the KPU loads the pre-trained model, and calls the camera API interface to turn on the camera; the camera will be turned on by waiting for the turn-on command sent by the Hi3861, and then, if the command arrives, the camera will be turned on. Open the face recognition, send back the unlock command after successful recognition, and send back the unlock failure command after failure.

3.2 Fingerprint Recognition Module Design

Write the driver file, in the variable definition, complete the module LED control, enrollment fingerprints, verify fingerprints, search fingerprints, delete fingerprints and other instruction definition; and complete the initialization module function, communication protocol function, get fingerprint image function, generate features function, fingerprint search function, delete instruction function, control LED function, integrated fingerprint identification function, fingerprint enrollment function writing. In the Hi3861 code, we initialize the fingerprint recognition module in the fingerprint recognition task, wait for the successful fingerprint recognition, if the recognition is successful that is to open the door, if the recognition fails to perform the buzzer alarm to indicate the failure of unlocking.

3.3 Keypad Input Module Design

Due to the limited I/O resources of Hi3861, it can't support the matrix keyboard, so it adds PCF8574 I/O expansion chip. Write the PCF8574 driver file, set the I2C slave address of the module, complete the PCF8574 write data, read data function; complete the initialization function; complete the key scanning function; complete the password setup function; complete the password input function; complete the password detection function; complete the password storage bit checking function, and send back the corresponding password registration instruction according to whether the Hi3861 is detected or not. According to whether Hi3861 flash password is detected or not, the corresponding password registration instruction will be sent back.

3.4 NFC Recognition Module Design

Write NFC driver file, in the driver file, complete the relevant initialization instructions, card-seeking instruction definition; complete the module initialization function writing; complete the module wake-up function and card-seeking function writing.

3.5 Huawei Cloud IOT Platform Connectivity Design

In this project, we use the MQTT protocol to connect to Huawei Cloud. First, we write the driver file for the MQTT protocol to complete the software foundation for connecting to Huawei Cloud; second, we complete the creation of this product and the construction of the online device on the Huawei Cloud IOT platform, and generate the corresponding Client ID and Password, and add the product domain name in the MQTT driver file.

3.6 Hi3861 code flow design

In Hi3861, we use the OpenHarmony system, according to the OpenHarmony system characteristics, after writing the program of each module, we complete the task creation and task scheduling of each module in the Hi3861 main program. First, complete the definition of the data used, including the WIFI name and WIFI password for connecting to the network, and the Client ID, user name, and password for connecting to the Huawei cloud platform; second, in the main function, complete the initialization of each module and configure the relevant I/O for the specified function, complete the creation of the four tasks, and allocate reasonable space resources and priorities; after the main function is completed, in turn Write each task function and door lock open success, door lock open failure and other functions.

3.7 Design of data communication protocol between Hi3861 and K210

Hi3861 and K210 communication protocol, we take as simple as possible to ensure the smoothness of the communication protocol. In terms of communication interface standard, we choose the serial port TTL level, baud rate 115200, 8 data bits, 1 stop bit, no parity, Hi3861 and K210 have to follow this interface standard in order to communicate. We use the frame format of frame header, data bits and frame tail to encode the data frame, and the specific format is shown in Table 1.

Table 1. communication protocol table

Name	Data	Function
Head of frame	0x55	Used to determine the header of a data frame
Unlock	0x01	unlocking
Face recognition	0x11\0x22	Turn on Face Recognition \ Turn off Face Recognition
End of frame	0x88	Used to determine the end of a data frame

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4. SYSTEM IMPLEMENTATION AND TESTING

4.1 System Implementation

The system divides the functionality into four tasks, which are executed sequentially in OpenHarmony, with each task executing an unlock command when the corresponding unlock requirement is met.

4.2 System Testing

In the system integration test, we add each module in turn and conduct a comprehensive test step by step. Firstly, the key input module and fingerprint recognition module are added to verify the coexistence of these two modules and the running effect of the program; then, the face recognition module is added to check whether the overall operation of the system is normal and to observe the response time of the unlocking to ensure its efficiency and accuracy; finally, the NFC recognition module is accessed to comprehensively verify whether the operation of the whole system is correct. The serial port of each module system test is shown in Figure 5, which shows in detail the performance of each module after integration and provides important data support for subsequent system optimization and debugging.

The accuracy of frontal face recognition is 90.5%. Although side face or wearing decorations may affect the accuracy of recognition, it has little effect on normal face recognition. This indicates that the designed access control system performs well in face recognition. The effect of face recognition is shown in Fig. 6.

Figure.4 System Test Serial Port Schematic

Figure.5 Face Recognition Effect

5. CONCLUSION

This project aims to develop an intelligent access control system based on OpenHarmony operating system, which completely localizes and integrates Huawei Hi3861 IoT chip and Sipeed K210 AI processing module to realize a highly secure and intelligent access control solution. The system not only improves the security level of traditional access control, but also provides advanced technical support for the construction of smart communities by integrating various intelligent functions such as face recognition and remote control, which significantly improves the user experience and management efficiency, and meets the dual needs of modern society for security and convenience

6. REFERENCES

[1] Liao M P, Yu C W, Wang Y J, et al. Design and realization of “one-shake-open” live fingerprint door lock system[J].Chengdu Journal of Information Engineering,2020,35(01):22-25.

[2] Zhao Q C. Research on face recognition system based on machine learning[J]. Inner Mongolia Science and Economy,2024,(14):115-118..

[3] Bai X, Wang X, Guo W J. Research on the present and development trend of electronic door locks at home and abroad[J]. Inner Mongolia Science and Economy,2021,(13):97-99+101.

[4] Wu C, Zhang J B, Li H X et al. Two-dimensional code access control system based on STM32 microcontroller[J]. Science and Technology Innovation and Application,2024,14(25):49-52..

[5] Zou Z Y, Liu J F. Design of intelligent restaurant system based on Harmony Hi3861 and STM32 dual control[J]. Internet of Things Technology,2023,2023,13(01):85-88.

[6] He R T. Design of mask face detection and temperature measurement system based on K210[J]. China Science and Technology Information,2023(11):74-76+79