Design of a multifunctional entrance guard system using GSM and fingerprint identification

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Abstract. Conventional entrance guard systems have monotonous functions. This paper designs an entrance guard system that takes the STM32 single chip machine as the control center and has the fingerprint identification module, GSM short-messaging module, the call notification module to realize local and remote unlocking (door opening) operations. Touch display screens and the STemWin graphics software are combined to design the human-computer interaction interface. The external memory module is designed to record the unlocking time and the historical data about the door opener. This designed system has diverse functions, secure, convenient for operations and can realize visualization of human computer interaction.

1. Introduction
With the wide adoption of electric and computer technologies, intelligent doors come into being. This study, on the basis of low cost and high security, uses technologies including STM32 single chip machine, GSM and fingerprint identification, develops a new way of unlocking that realizes remote and local unlocking, making the entrance guard system more diversified, human and convenient.

2. System overview
Figure 1 shows the structure of the hardware system. The 32-digit single chip machine STM32F103VET6 with 32F103VET6 as the kernel is used as the control center. The GSM module is used for remote short-messaging and call unlocking control, and the optical fingerprint module is used to realize local unlocking control. The touch display module is used for human computer interaction. The EEPROM in the external memory module is used for storage of data including unlocking history and the door opener’s information. The Flash is used for storage of texts and images. The press buttons are used to remind the one inside the room to open the door. If not operated within 5 min, the system will enter the sleep mode, and will be awaken if the unlocking operations begin or if the button is pressed. The speaker is driven by the power parts to send sounds of doorbell or operation descriptions. The electronic door lock is made of a motor and driving circuits. The proximity switch is used to detect whether the door is open or locked, and it is detected that the door is locked, the lock will be locked. Figure 2 shows the actual system.
3. Hardware design

3.1. GSM module
Remote control of the system is realized by GSM short-messaging and call. The GSM module consists of the SIM800C module, the start circuit, SIM card interface circuit, the main antenna circuit.

3.1.1. SIM800C module. The SIM800C module is a low-power four-frequency GSM/GPRS module, a 2G mobile phone communication module that supports four working frequencies and has functions like SMS, voice call and mobile data transmission [1]. The circuit of the SIM800C module is shown in Figure 3. VCC-BAT is 4.1V power input, PWRKEY is the module start interface, GSM_TX, GSM_RX are the sending and receiving terminal of the ports of the single chip machine, STATUS is the pin of the working mode, and the high level is output when the module works. SIM_DET, SIM_DATA, SIM_CLK, SIM_RST, SIM_VDD represent the in-place detection, data input and output, clock, recovery and power module, and the connection with the external SIM card port of the SIM card.
3.1.2. SIM card port circuit. The SIM card is used for identification in the GSM module. The SIM card port circuit is shown in Figure 4. The I/O pin of the SIM card port is connected to the SIM-DATA of SIM800C. The resistors R16, R17 and R18 are used to match the communication lines. C28, C29 and C30 are the bypass circuits that filter the high-frequency noises. SMF15C is used to protect the SIM and avoid impacts from the surges. Five TVS tubes are installed into the SMF15C module to provide five-path protection against static electricity. Under high temporary power shocks, TVS can be converted to low resistance from high resistance quickly, direct the shock to the ground to avoid damages on the parts [2].

3.1.3. Antenna circuit. In order to increase the signal receiving and sending capacities of the GSM module, an antenna circuit is set, as shown in Figure 5. Resistors and capacitors are designed for
impedance matching to ensure that the circuit resistance from the GSM_ANT pin of the SIM800C to the antenna ANT1 is 50Ω and is not subject to sources of strong disturbance [3].

\[ \text{Figure 5. GSM antenna circuit.} \]

\[ \text{Figure 6. GSM Start circuit.} \]

3.1.4. Start circuit. The SIM800C module can be started by connecting the PWRKEY pin with low level, as shown in Figure 6. The start circuit consists of PNP triodes, resistors and capacitors. When the PWRKEY_GSM pin connected to the single chip machine is high level; when the triodes are turned on, the PWRKEY pin of the SIM800C chip is connected to the ground at low level, i.e. to realize the start operation.

3.2. Optical fingerprint module
The optical fingerprint module is used for local unlocking operations and realized by the optical fingerprint processor AS608. The processor is an embedded high precision fingerprint algorithm fingerprint security chip, a 32-digit RISC processor, an embedded specific DSP, fingerprint algorithm and fingerprint processing accelerator that supports fingerprint sensors [4]. The single chip machine sent format-specific command packages to the fingerprint module via the UART series port. That is, it can realize operations of the fingerprint identification module, the fingerprint identification module returns the answer package and inquire the execution conditions according to the answer package.

3.3. Touch display screen module
The touch display module is used for human computer interaction. On the display, the user can input dynamic codes, view or delete historic data, add, delete or revise authorities of users. The module consists of an LED display circuit, a touch screen and a light regulation circuit. The LED display circuit consists of a 16-digit true-color 4.3-inch TFTLCD display and the motor NT35510, calls the STemWin graphics function port to realize operations like drawing dots, lines and image display on the screen. The touch display module consists of a projective capacitor touch screen and the detection motor ICOTT2001A. The single chip machine reads the register of the OTT2001A chip, and in combination with the display, realizes integrated control of touch display.

3.4. Electric control door lock
This system uses independent electric control door locks, as shown in Figure 7. RELAY is connecte to the PA15 pin of the single chip machine, and when the PA15 pin output high level, the transistor is connected and the door opens. When the PA15 pin outputs low level, the door closes.
3.5. External memory module

The historic data of the system and the information of authorized users are stored by the EEPROM chip AT24C512. AT24C512 is a 64KB serial electrically erasable programmable memory that supports I2C bus interface to read and write data. The working voltage is 1.8V ~ 5.5V.

The texts and images of the system is stored by the Flash memory W25Q80. The capacity of the W25Q80 is 8M and supports SPI data reading and writing, and the clock is 104MHz[5].

4. Software design

Figure 8 shows the software structure of the system. When the system is powered, all modules are initialized, and then the fingerprint identification module, the GSM module, the touch display module, the button press module are scanned, the scanning result from which are then serve as a basis for subsequent operations [6].

The fingerprint module program is designed to realize fingerprint input and fingerprint identification. The input function is used to build a user authorization fingerprint database, and only when a fingerprint is entered three times can it be loaded into the fingerprint database. In the fingerprint identification process, the system first detect whether the fingerprint is entered via the sensor, then reads the fingerprint by sending commands to generate features for matching and authentication. When authenticating a fingerprint, the system will match the fingerprint with one in the database to determine whether the user is an authorized user.
The GSM module is used to realize unlocking via SMS and calls. An authorized number sends SMS to the system, and when the first character is sent, the door is opened. When a series of characters are sent according to the characters on the display, the door is opened, i.e. to set dynamic locking codes via SMS. Dynamic codes can be used to open doors for unauthorized users via remote control. To be specific, the authorized phone number make GSM calls to the system and the door will then be opened.

5. Conclusions
This system, via the GSM and fingerprint identification module, allows the user to open the doors via mobile phone calls or fingerprint identification. It increases the function of human-computer interaction, allows the users to view history, add and delete authorized users, which is easy to use and has good anti-theft and anti-decoding performance.

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