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Epidemic-proof smart dorm system based on STM32

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Abstract: *With the frequent occurrence of public health incidents in recent years, the health and safety management of dormitories, as the main place for students' daily life, has received increasing attention. In order to more effectively respond to public health emergencies and protect the health and safety of student rest areas, a hardware point cloud interconnected dormitory monitoring and early warning design scheme is proposed by combining IoT technology and image processing recognition technology. This paper designs a smart epidemic prevention dormitory system based on a micro-controller, focusing on monitoring and controlling the dormitory environment, including temperature, humidity, air quality, and lighting, providing real-time monitoring and alarm functions. The integration of IoT, image processing, and micro-controller technology in the system makes it a solution for dormitory management, providing a comprehensive and efficient way to monitor and control the dormitory environment.*

Keywords: *Smart dormitory, Internet of Things, Embedded System, Real-Time Operating System, Feature Detection*

1. Introduction

With the frequent occurrence of public health incidents in recent years, the invasion of viruses and bacteria into the human body has caused epidemics that pose a threat to the health and safety of all humanity. Since the COVID-19 epidemic, the unknown epidemic caused by viral and bacterial infection has made us more afraid. How to prevent the unknown epidemic has become another important problem that people face. Dormitories, as the main place for students' daily life, are also a key area for the breeding and transmission of infectious diseases. People's attention to health is increasing. Campuses are important places with high population density, and epidemic prevention work in student dormitories is particularly important.

In today's society, smart dormitory systems are gradually becoming an important part of improving the quality of campus life[1]. With the development of Internet of Things (IoT) technology, the intelligent management of student dormitory environments has gained widespread attention[2]. Traditional dormitory management methods typically rely on manual inspection and maintenance, which are inefficient and prone to errors[3]. In contrast, smart dormitory systems integrate various sensors and control modules to achieve automated environmental monitoring, device control, and security management, significantly improving management efficiency and dormitory safety[4].

The goal of this study is to design and implement a smart epidemic prevention dormitory system based on STM32 micro-controller. By integrating various sensors and communication modules, the system aims to achieve intelligent monitoring and control of the dormitory environment to prevent unknown epidemics. This article will provide a detailed introduction to the hardware design and software implementation of the system.

2. Core Control Board and Module Integration

This system takes intelligent dormitory as the research object, which uses STM32F103 as the main control system to control other modules, among which there are ESP8266 WIFI module, GY-906 infrared temperature measurement module, RC522 swipe card module, resistive serial screen, environment detection module (temperature, humidity, smoke, etc.), and disinfecting module (nebulizer, etc.). At the same time, V831 is used for face detection and the processed data is sent to STM32F103 through the serial port, and the corresponding modules are controlled according to the face data information it sends. The specific hardware system design is shown in Figure 1

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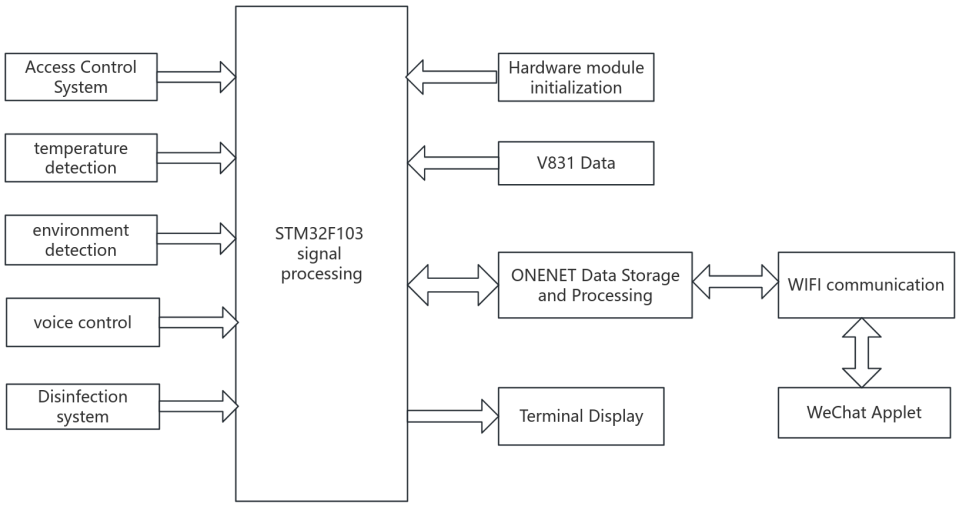

Figure 1: System Block Diagram

This system needs to be all in addition to using the ESP8266 module to connect to the AliCloud platform to realize the communication between the WeChat applet and AliCloud as well as the communication between AliCloud and the micro-controller.

This paper uses an STM32F103ZET6 micro-controller with a Cortex-M3 core.STM32 micro-controller has the following main features[5]:

1) STM32 belongs to a version of the arm kernel, more advanced than the traditional 51 micro-controller, there are a lot of resources 51 does not have, such as a USB controller. Speed is not 51 can be compared.

2) STM32 micro-controller programs are modular, the interface is relatively simple, because it with a good multi-function, working speed is also fast. The 51's function is less, needs more peripheral components, and requires familiar with the electronics.

3) The STM32 interconnect series products enhance audio performance with an advanced phase-locked loop mechanism that enables audio-grade I2S communication. Combined with USB host or slave functionality, the STM32 can read, decode, and output audio signals from external memory (USB flash drive or MP3 player).

4) STM32 is a 32-bit flash micro-controller based on the ARM ® Cortex ® M processor core, for MCU users to open up a new free development space, and provides a variety of easy-to-get-started hardware and software aids.STM32 MCU integration of high-performance, real-time, digital signal processing, low-power, and low-voltage at the same time, while maintaining a high degree of integration and development of easy features. The industry's strongest product lineup, industry-standard-based processors, and a wide range of hardware and software development tools make STM32 MCUs ideal for all types of small and medium-sized projects and complete platform solutions.

5) In addition to the new feature-enhanced peripheral interfaces, the STM32 interconnect family offers the same standard interfaces as other STM32 micro-controllers, the schematic of which is shown below in Figure 2. This peripheral commonality enhances application flexibility across the entire family of products, allowing developers to reuse the same software in multiple designs. Standard peripherals for the new STM32 include 10 timers, two 12-bit 1-Msample/s analog-to-digital converters, two 12-bit digital-to-analog converters, two I2C interfaces, five USART interfaces, and three SPI ports. The new product peripherals have a total of 12 DMA channels, as well as a CRC calculation unit that, like other STM32 micro-controllers, supports 96-bit unique identification codes.

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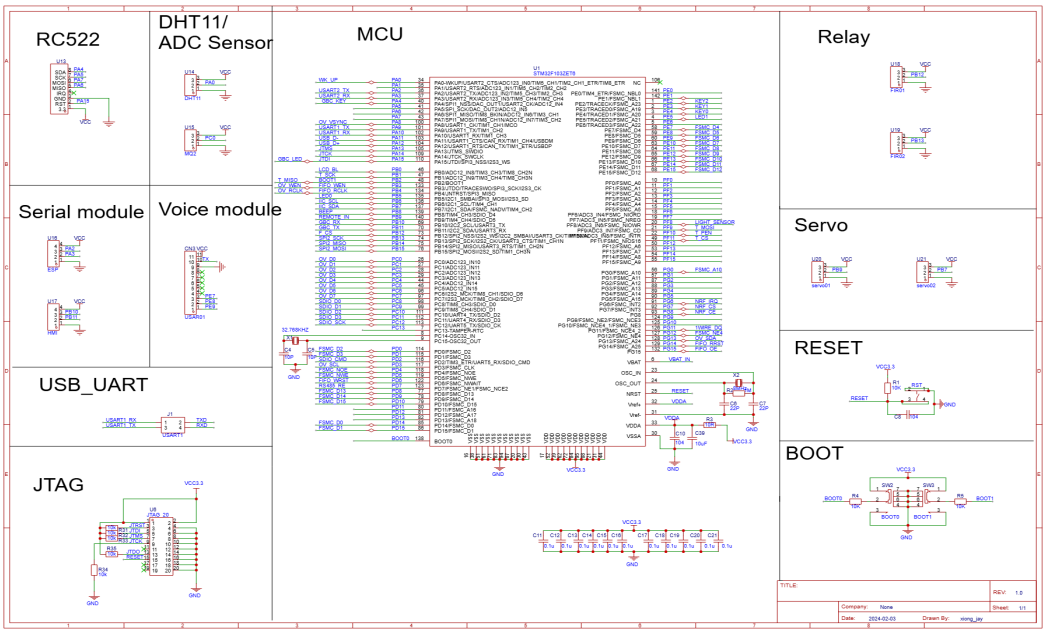

Figure 2: General Project Schematic

6) The new series of micro-controllers also continues the STM32 product family's strengths of low voltage and energy efficiency. 2.0V to 3.6V operating voltage range is compatible with mainstream battery technologies such as Li-Ion and Ni-MH batteries, and the package also features a dedicated pin for the battery operation mode, Vbat. Executing the code from the flash memory at a frequency of 72 MHz consumes only 27mA of current. Four low-power modes reduce current consumption to two micro-amps. Fast booting from low-power modes also saves power; the boot circuit uses the STM32's internally generated 8MHz signal to wake the micro-controller from stop mode in less than 6 microseconds. A physical diagram of the STM32F1ZET6 is shown in Figure 3.

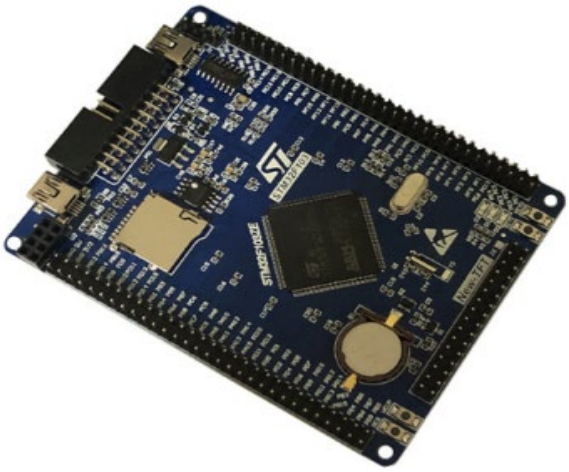

Figure 3: STM32F103ZET6 physical diagram

3. Power Management and Controller Module Design

This chapter will introduce more details about the voltage regulator module and the control modules. The power supply voltage of the controller is 5V, the power supply voltage used for OLED display, etc. is 3.3V, and the power supply voltage is 12V, so it is necessary to use a voltage regulator module for DC-DC voltage conversion. This paper uses the LM2596S DC-DC DC adjustable buck voltage regulator module board, the module can drop three voltages were 3.3V/5V/adjustable voltage, at the same time in terms of security with TTL power-off capability, easy to interface with logic circuits at the same time to do for the protection of the connected devices. Standby mode, its typical value is as low as 80uA, which helps to save energy, is a better choice, the voltage regulator module physical diagram is shown in Figure 4.

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Figure 4: Voltage Regulator Module Physical Diagram

The controller section will cover the WIFI module, infrared temperature measurement module, swipe card module, and screen in detail.

The ESP8266 WIFI module model NodeMcu Lua WIFI V3 is used in this design. The module is a low-cost, low-power Wi-Fi chip developed by Espressif Systems with a complete TCP/IP stack and microcontroller. The ESP8266 supports two modes of operation, namely, Access Point Mode (AP) and Site Mode (STA). In AP mode, the ESP8266 can act as a server or client; in STA mode, it can connect to other network devices to act as a server or client. The module's operating voltage is 3.3 V. The integrated MCU inside the module can communicate with the microcontroller through the serial port. In this design, the ESP8266 connects to the onenet through AT commands, and the STM32 MCU connects to the ESP8266 through the serial port and sends the AT information needed for the ESP to connect to the onenet to the ESP through program writing so that the ESP connects to the AliCloud IoT platform and communicates with the STM32 MCU to transfer data. The ESP8266 module is shown in Figure 5

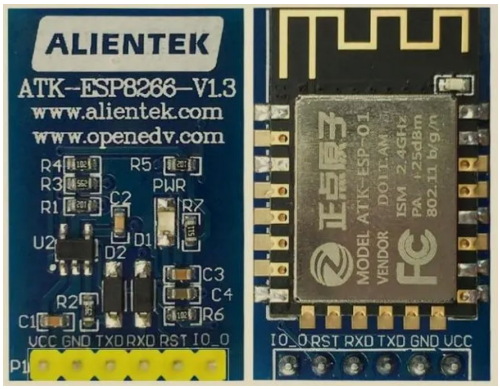

Figure 5: ESP8266 Physical Figure

The GY-906 Infrared Temperature Sensor Module is a powerful and versatile temperature detection device suitable for use in a variety of applications where accurate temperature measurement is required. The temperature measurement range is typically from -40 to 125 degrees Celsius, while the object temperature measurement range can be extended to -70 to 380 degrees Celsius, with a margin of error of approximately ±0.5 degrees Celsius. The GY-906 series consists of different models, such as GY GY-906-BAA (or DAA, measuring distance 2CM), GY-906-BCC (or DCC, measuring distance 10CM) and GY-906-DCI (measuring distance 1M), to meet the needs of different measuring distances, this time we chose the DCI series can be measured in the farther away to reduce the contact infections, the physical picture is as follows Figure 6.

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Figure 6: GY-906-DCI Physical Drawing

The V831 is a high-performance, low-power single-core Cortex-A7 processor from Allwinner Technology with a large number of pin interfaces to choose from (Figure 7), as well as access to cameras and expansion boards for use with machine vision and to send information. Primarily aimed at video encoding and AI acceleration applications the chip has 64MiB of on-chip DDR2 memory to meet basic computing needs. It integrates the latest technology ISP (Image Signal Processor) and various image correction algorithms, such as wide-angle distortion correction and PTZ (pan, tilt, zoom) correction, to achieve professional image results. The V831 supports hardware AI acceleration with 0.2Tops of arithmetic power, which can be used for edge AI applications such as running the yolov2 algorithm with speeds of approximately 45ms to 60ms. The V831 is a versatile SOC that can be used as a general Linux SOC or specialized for AI scenarios that require edge computing power. Its high integration and low power consumption make it advantageous in the field of embedded systems and smart devices Based on the above characteristics this paper chose it as our vision processor.

V831, as a microprocessor based on RISC-V architecture, it is often applied in the field of artificial intelligence, especially in the application of facial recognition technology (Figure 8). In the process of using V831 for facial feature detection, several key steps are involved, including model loading, facial detection and addition, as well as facial feature recognition and matching.

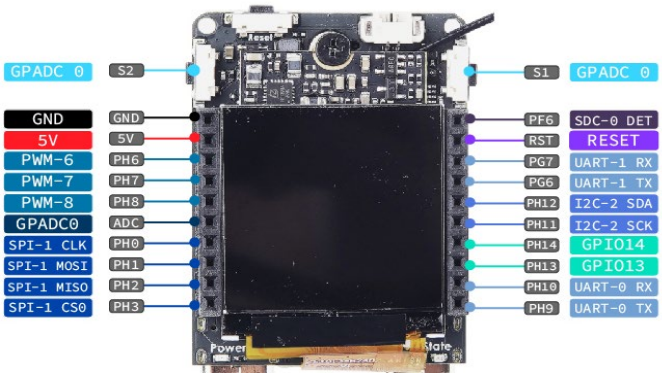

Figure 7: V831 and its pins

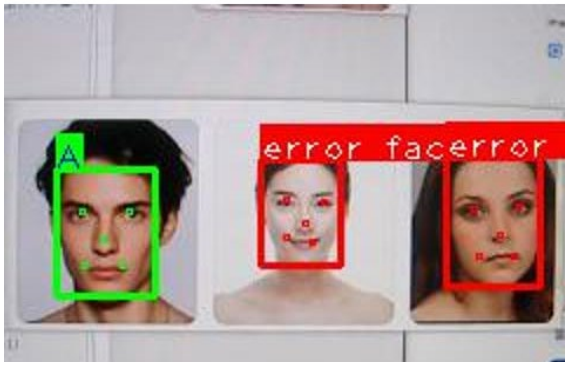

Figure 8: Facial feature recognition

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Serial Screen is an intelligent display terminal, usually used in embedded systems to provide a user interface. Serial Screen is based on ARM architecture embedded industrial control system with industrial grade ARM processor as the core, which means it has better processing power and stability. It integrates a TFT LCD and a touch screen, providing a rich display and convenient user interaction. This makes the serial screen ideal for applications that require a graphical interface. As a kind of human-machine interface, the serial screen makes the operation of the machine more intuitive and humanized. The type of screen is divided into the resistive screen and capacitive screen we use the type of resistive screen, because of its resistive touch screen part of the screen is a multilayer composite film, by a layer of glass or plexiglass as the base, coated with a transparent conductive layer (ITO film), above and then cover a layer of hardened surface treatment, smooth and scratch-resistant plastic layer, which can be used to further play a role in the protection of the screen. When the finger contact screen, the two layers of ITO contact, resistance changes, the controller according to the detected resistance changes to calculate the coordinates of the contact point, and then by the coordinates of the corresponding operation, to achieve the role of the touch screen. As shown in Figure 9.

Figure 9: Resistive Serial Screen

4. Real-Time Operating System

Using the FreeRTOS operating system allows developers to create multiple tasks and assign different priorities to each task. This helps ensure that critical tasks receive sufficient CPU time, while lower priority tasks can be executed when the system is idle. This can effectively allow for effective communication and resource sharing between tasks. One of the challenges is to ensure efficient and stable communication between different modules. Due to the involvement of multiple communication protocols and methods, such as Wi Fi, Bluetooth, Ethernet, and data exchange between multiple sensors and devices, without an effective task management and scheduling mechanism, it is easy to encounter data conflicts, deadlocks, and even system crashes.

Conventional single core processors can only perform one task at a time, but multitasking operating systems can quickly switch tasks, making all tasks appear to be executing simultaneously. The following figure shows the execution patterns of three tasks relative to time. The task name is marked in different colors and written on the left side. Time moves from left to right, with colored lines displaying tasks executed at specific times. The perceived concurrent execution pattern is shown above, and the actual multitasking execution pattern is shown in Figure 10.

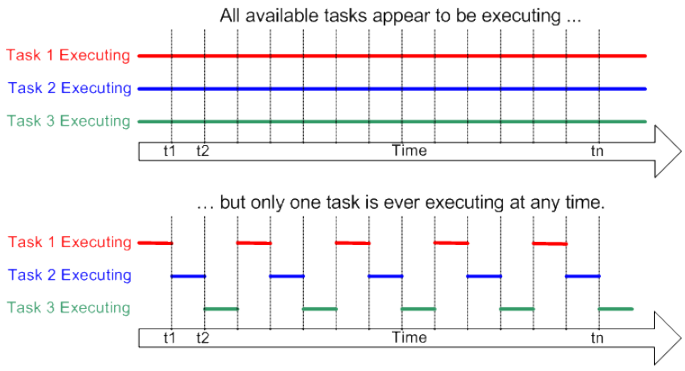

Figure 10: Multi tasking and concurrency

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5. Conclusion

This study presents the design and implementation of a smart dormitory system based on the STM32F103 micro-controller, which integrates various sensors and communication modules to achieve intelligent monitoring and control of the dormitory environment. The system significantly enhances management efficiency and safety by utilizing advanced features of the STM32 micro-controller, the ESP8266 WiFi module for seamless communication with the AliCloud platform, the GY-906 infrared temperature sensor for accurate, non-contact temperature measurement, the RC522 swipe card module for secure access, and the V831 processor for advanced functionalities such as face recognition.

Overall, the smart dormitory system demonstrates a substantial improvement in dormitory management through IoT technology, providing a more efficient and secure living environment for students. The combination of robust hardware design, efficient power management, and advanced communication capabilities ensures that the system can meet the demands of modern dormitory environments. Future developments could focus on expanding the system's functionalities, exploring additional applications of IoT technology in campus life, and further enhancing the overall quality of student living conditions.

Acknowledgement

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