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Design of Multi-Functional Fan Based on Single-Chip Microcomputer

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Abstract: *This paper designs and implements a multi-functional fan based on a single-chip microcomputer. The fan is equipped with multiple working modes including manual control, environmental sensing, automatic adjustment, environmental regulation and timing. It also supports voice control and remote monitoring via a mobile APP, enabling functions such as fan gear adjustment, environmental data viewing and related threshold setting, and can intelligently adjust its operating status according to environmental changes. This design realizes the intelligent upgrading of traditional fans, improves the convenience and comfort of use, and effectively reduces energy consumption. It provides new ideas and practical references for product research and development in the smart home field, and has good application value and promotion prospects.*

Keywords: *Intelligent fan; Intelligent control; Internet of Things (IoT)*

1. Introduction

With the rapid development of the Internet of Things (IoT) technology and the ever-increasing demand for smart home life, comfort and intelligence have become important development trends for household electrical appliances[1]. Traditional fans feature a single function and lack the capabilities of environmental sensing and intelligent regulation, making it difficult for them to meet the current usage needs of users and the development requirements of the industry. To this end, this paper designs a multi-functional fan based on a single-chip microcomputer. The device can realize multiple working modes such as manual control, automatic adjustment and environmental regulation, and supports voice control and remote monitoring[2]. It is capable of intelligently adjusting its operating status according to environmental changes. With a rational design scheme and practical functions, the fan boasts good promotion and application value in the field of smart home production.

2. Overall System Structure

The hardware of this system takes the STM32F103C8T6 single-chip microcomputer as the main control core, and is composed of hardware modules including an environmental sensing sensor, a display module, a voice control module, a wireless communication module, manual key modules and a fan drive module. Each module performs its own duties and cooperates with one another to complete the core functions such as environmental data collection, instruction receiving and processing, fan operation control and data interaction[3]. The system adopts a three-layer architecture consisting of a perception layer, a transmission layer and an application layer. The perception layer is responsible for environmental data collection; the transmission layer completes data interaction via WIFI; and the application layer realizes user interaction and remote control by taking a mobile APP as the carrier[4]. The overall structural design of the system is shown in Figure 1.

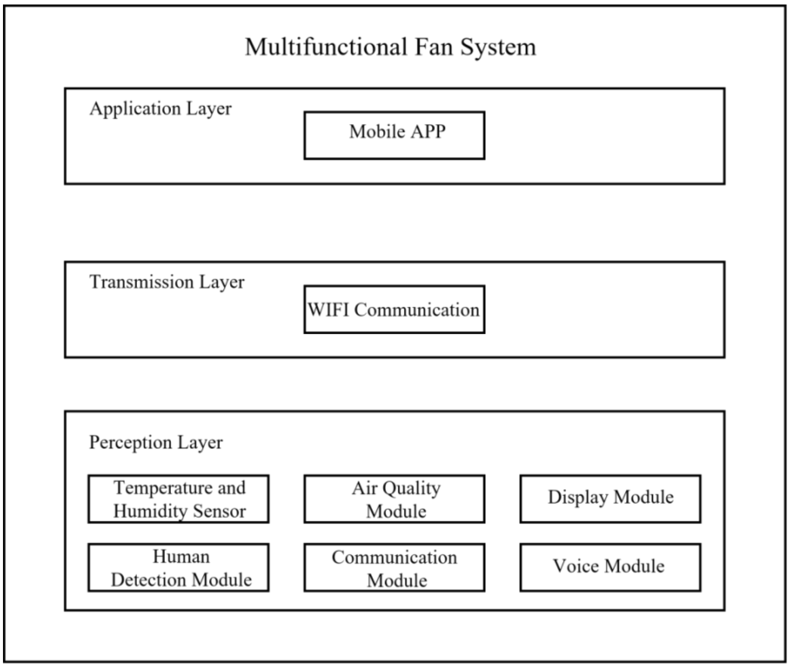

Figure 1: System Architecture Diagram

2.1. System Hardware Design

The hardware design of this system takes the modular design concept as the core. Centering on the requirements for intelligent sensing, control and interaction of the multi-functional fan, a hardware architecture is built with the main control module as the core, integrating functional modules such as sensing, display, control, communication, drive and power supply[5]. Each module has a clear division of labor and cooperates with each other to realize the full-process hardware functions including environmental data collection, operating status display, local and remote control, and instruction execution, which provides a solid hardware support for the intelligent operation of the fan[6].

2.1.1. Main Control Module

A high-performance single-chip microcomputer is selected as the main control module of the project system, and the sensing module integrates three types of sensors: temperature and humidity, human body infrared, and air quality sensors[7]. The high-performance single-chip microcomputer is equipped with abundant peripheral interfaces and efficient data operation and processing capabilities, which can efficiently complete system instruction operation, data processing and the coordinated work of each module. It provides hardware support for the convenient access of various sensors and communication modules, and ensures the high efficiency of data transmission and processing. The three types of sensors are respectively adapted to digital or analog signal output, featuring strong compatibility with the main control module and fast detection response speed. They can realize real-time and accurate collection of environmental temperature and humidity, human presence status and air quality, thus providing reliable environmental data support for the intelligent adjustment of the fan.

2.1.2. Display Module

A simple and practical character display device is adopted for the display module of the project system, and the control module consists of manual rebound keys and a voice control module. The character display device has a simple interface and low power consumption, and can be stably connected to the main control module through general I/O ports. It can display key information such as environmental temperature and humidity, air quality, fan gear and working mode in real time, realize the visualization of the system operating status, and facilitate users to intuitively grasp the working condition of the device. The manual rebound keys can complete the local manual switching of fan gears and working modes, meeting users' basic local operation needs. The voice control module supports voice command recognition with flexible and convenient operation, which can realize voice-controlled start/stop, gear adjustment and mode switching of the fan, and greatly improve the convenience and diversified experience of human-computer interaction[8].

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2.1.3. Communication Module

A WIFI communication module is selected as the communication module of the project system, with a fan drive module and a power supply module designed as supporting components. The WIFI communication module supports wireless networking and features the advantages of long transmission distance and high stability. It enables two-way data interaction between the hardware system, mobile terminals and cloud platforms, fulfills the reception of remote control instructions and the upload of environmental data, and thus provides reliable network support for the remote monitoring and control of the fan[9]. The fan drive module can accurately receive control signals from the main control module, realize flexible adjustment of the fan motor speed and switch fan gears to meet different air speed requirements. The power supply module takes both low power consumption and stability into account, which can provide a stable working voltage for the entire hardware system, adapt to different power supply scenarios, and fully ensure the continuous and normal operation of all hardware modules.

2.2. System Software Design

The software design of this system adopts a modular programming idea. Centering on hardware functions and intelligent control requirements, it is divided into two core parts: the single-chip microcomputer-side program and the mobile terminal APP program. Based on the MQTT protocol, the two realize two-way data interaction through a cloud platform. Each functional subprogram has a clear division of labor and is scheduled collaboratively, completing the full-process software functions such as data collection and analysis, mode logic control, human-computer interaction and remote communication. It provides a complete software support for the intelligent and convenient operation of the multi-functional fan. The overall flow of the system software is shown in Figure 2.

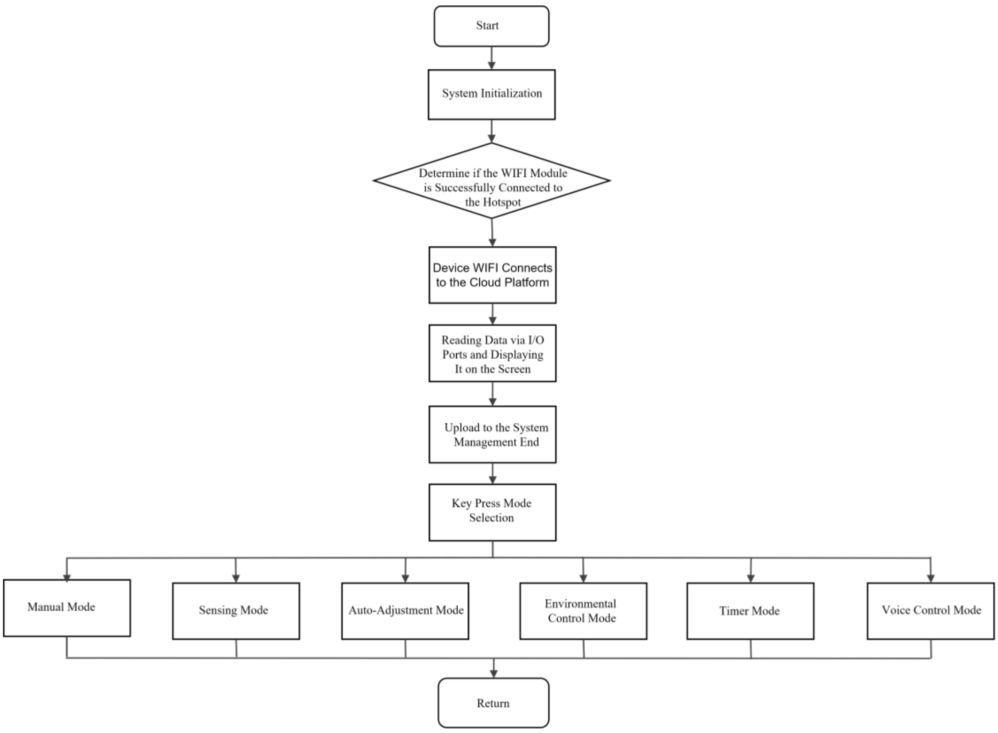

Figure 2: Flow Chart of the Software System

2.2.1. Single-Chip Microcomputer Side

As the core of software control, the single-chip microcomputer side conducts program writing and debugging based on the KEIL5 development platform, with code development completed in the C language. The overall program is divided into the main program, sensor data collection subprogram, mode control subprogram, human-computer interaction subprogram, communication subprogram and display subprogram according to functions. All subprograms are uniformly scheduled by the main program to ensure high efficiency in data processing and instruction execution. The main program is responsible for system initialization and cyclic scheduling of functions. After power-on, it completes the initialization of peripheral devices such as the single-chip microcomputer's I/O ports, timers, serial ports and ADC, as well as the reset and parameter configuration of various sensors, voice modules and

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communication modules. Upon completion of initialization, it enters a cyclic scanning state and calls each functional subprogram in sequence to achieve real-time data collection and real-time instruction response.

2.2.2. Sensor Data Collection Subprogram

Aimed at the communication protocols and data output formats of three types of sensors (DHT11, SR501, MQ135), the sensor data collection subprogram is written with exclusive data reading and parsing code to realize accurate collection and digital conversion of temperature and humidity, human presence signals, and air quality analog quantities. The collected raw data is filtered to eliminate errors caused by environmental interference, providing a reliable data source for the intelligent control of the fan. The mode control subprogram is the core functional module, which contains the control logic of five modes: manual, sensing, automatic adjustment, environmental control and timing. According to the data collected by sensors, manual key instructions, voice instructions or remote APP instructions, it judges and executes the corresponding fan control strategies to complete the start/stop and gear adjustment of the fan. Meanwhile, it supports seamless switching between various modes to meet the usage requirements in different scenarios.

2.2.3. Human-Computer Interaction Subprogram

The human-computer interaction subprogram consists of two parts: key scanning and voice recognition & parsing. The key scanning subprogram adopts external interrupt or timing scanning methods to identify the pressed state of manual rebound keys, parse the gear adjustment and mode switching instructions, and transmit them to the main program. The voice recognition subprogram performs serial port communication with the ASRPRO Tianwen voice module, receives the voice instruction data recognized by the module, and parses it into control signals such as fan start/stop, gear adjustment and mode switching to realize voice control. The display subprogram is written based on the communication protocol of the LCD1602 display module, which outputs real-time collected environmental data, the fan's current working mode, operating gear and other information to the display module in a fixed format, realizing visual display of the system status for users to view locally. The communication subprogram is developed based on the AT instruction set of the ESP8266 WIFI module, completing WIFI networking of the module, cloud platform connection and MQTT protocol configuration, thus realizing two-way data transmission between the single-chip microcomputer side and the cloud platform. On the one hand, it uploads environmental collected data and system operating status to the cloud platform; on the other hand, it receives remote APP control instructions issued by the cloud platform, parses them and transmits them to the main program for execution.

2.2.4. Mobile Terminal APP Program

The mobile terminal APP program is designed and developed based on the Android Studio development platform, with code writing completed in the Java language. The interface design follows the principle of simplicity and ease of use, and is divided into six modules: login interface, main interface, threshold configuration interface, real-time data interface, control center interface and historical data interface. The APP establishes a connection with the cloud platform through the MQTT protocol to realize remote data interaction with the single-chip microcomputer side; the control center interface supports remote switching of the fan's working mode and operating gear; the threshold configuration interface allows customizing the trigger thresholds of temperature, humidity and air quality as well as the timing duration; the real-time data interface synchronously displays the environmental collected data and system operating status issued by the cloud platform; the historical data interface enables viewing of environmental data and fan operation records stored on the cloud platform. Meanwhile, the APP is equipped with a hardware connection status detection function, which can feedback the communication status with the hardware side in real time to ensure the accuracy of remote control.

3. Conclusion

The multi-functional fan system designed in this project takes single-chip microcomputer technology as the core and integrates technologies such as sensor sensing, wireless communication and speech recognition to build an intelligent control system with hardware and software coordination. The system can realize real-time collection of environmental data and human body detection, support a variety of working modes, and have the functions of local voice and key control as well as remote monitoring and configuration via mobile terminals. It can intelligently adjust the fan's operating status

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according to environmental changes, realizing the intelligent and convenient management and control of the fan. With a rational design and stable functions, the system meets users' demands for the intellectualization of household equipment and provides practical references for the intelligent upgrading of traditional home appliances. It has good application and promotion value in the smart home field and plays a positive role in the practical application of Internet of Things technology in civil intelligent devices[10].

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