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Structure Design and Motion Control of Remote Tea Service Robot Based on Computer Technology Rt-thread

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Abstract: The development prospects of home service robots are broad, and they can provide services such as security monitoring, helping with housework, entertainment and leisure. At present, the domestic service robots on the market have disadvantages such as high price, large size, and low degree of intelligence, which can no longer meet the needs of market development. Today, with the rapid development of embedded systems and internet technologies, it is necessary to integrate these technologies to develop a cost-effective, small, and highly intelligent remote home service robot system. In this case, this paper designs a remote tea service robot based on Rt-thread technology, and studies the structure design and motion control of the robot. First of all, this article analyzes the current research status of embedded systems and determines the wireless network technology used in this article. Next, this article has carried on the overall design to the tea service robot function and the embedded system. Then, the remote control system of the robot is designed and researched. Finally, this article tests the robot's response speed and human-computer interaction function. The test results show that the robot's response speed is very fast and the human-computer interaction function is also very accurate.

1. Introduction

With the rapid development of embedded system technology, the performance of 32-bit microcontrollers has been greatly improved, which can fully meet the high performance, low power consumption, compact size, modularization of actual field applications of tea service robots, and cost-effective relatively high [1]. With the invention of Internet technology, network communication technology has quietly revolutionized the remote control technology of robots. Internet-based robot control technology continues to mature, and wireless local area network technology continues to develop. Wireless network technology not only has all the characteristics and advantages of traditional network technology represented by Ethernet and token ring network, but also has the characteristics of not being restricted by wiring and geographical environment [2-3].

The transmission distance breaks through the limitation of the short transmission distance of the traditional network. The dependence of wireless network communication on the infrastructure is less than that of the traditional network technology, and it is not limited by factors such as line laying. Communication can change with mobile devices, and this feature also greatly reduces the application cost of wireless network technology. Compared with other existing wireless technologies, wireless network technology has unique advantages suitable for the study of this article.

Chinese scholar Deng Zening pointed out that with the advancement of science and technology, computer technology has become increasingly mature, which has led to the application and development of service robots. From the perspective of the perception system of the mechanical structure driving system of the service robot, the functions and roles of each part of the service robot are deeply understood, the specific application of the service robot is researched, and the application characteristics and division of labor of the service robot under computer technology are analyzed [4]. Bao Guanjun analyzed and discussed the technical problems existing in the research of service robots from the aspects of structural design innovation, modeling and simulation technology, and manufacturing technology, and pointed out the key problems that need to be solved in the design, modeling and simulation, manufacturing and other aspects of the pneumatic drive structure [5]. Wei Xiang designed a home intelligent robot for the internet of things that makes life intelligent and simple and user-friendly. Through the combination of mechanical structure design, electronic control technology and the current emerging internet of things technology, it subtly solves the practical problems of household potential hazard detection and early warning, home light adjustment, clothing increase and decrease [6].

Equipped with a WFi module with a camera, mutual communication between mobile phones and tea service robots can be realized through the Internet [7-8]. The tea service robot sends the collected video information, environmental temperature and humidity, PM2.5 index, and smoke and flame alarm information back to the mobile phone, and displays it through the mobile phone's upper computer application software, which can monitor the home security status in real time, which is convenient and reliable. The tea service robot is also equipped with obstacle avoidance modules, LED light modules, voice interaction modules, so that it can be transformed into an education and entertainment robot. It can perform 6 interesting motion modes: friendly follow, explore and discover, avoid obstacles, investigate and collect evidence, obey instructions, and listen carefully. In the later stage, some other functions can be realized through programming, including the use of three-axis acceleration self-balancing, the use of speakers to play music, light shows, painting, path recognition and so on. On the whole, the remote tea service robot designed in this paper has certain practical significance.

2. The Overall Design of the Remote Service Robot System

2.1. Functional Design of Tea Service Robot

The tea service robots studied in this paper are divided into upper computer and lower computer. The upper computer hardware is based on mobile phones as the carrier, and the application software is developed based on the android system. There are two functions of the host computer, one is to control the movement of the tea service robot, and the other is to collect the sensory video screen [9-10]. When designing the PCB board, two PCBs are superimposed on each other. PCB1 integrates the most basic functions of a tea service robot. PCB2 leaves a certain amount of space for the subsequent addition of hardware modules. This design not only reduces the volume of the tea service robot, but also facilitates the debugging and upgrading of hardware modules. In the software design, first transplant the RT-thread real-time operating system. Then carry out modular programming under the framework of RT-thread real-time operating system. While improving real-time performance and stability, it also facilitates subsequent software management and upgrades. The tea service robot has two main functions, one as a security monitoring function. This function is very meaningful as the main function of the tea service robot. It is integrated with temperature and humidity detection sensors, flame alarm sensors, smoke alarm sensors, cameras, which are used for home security monitoring. Another function of the tea service robot is the education and entertainment function. You can switch between six sports modes through the direction keys of the host computer. There are friendly follow, exploration and discovery, avoidance of obstacles, investigation and evidence collection, obedience to instructions, and careful listening, and then press the OK button to select the current sports mode.

2.2. Embedded System Overall Design

When designing the hardware circuit in this paper, fully consider the modular structure, so that the follow-up can be better upgraded and developed [11]. The core of the hardware design is based on a microcontroller equipped with the RT-threxd real-time operating system. On the basis of the microcontroller, hardware modules are added according to the realized functions [12]. The first is the most basic design of a tea service robot. The tea service robot must first be able to move. The motor drive module is the core of the tea service robot, and how to make the robot move more stable and accurate is a focus of this article. The software system is based on the RT-thred real-time operating system as the main program design framework and adopts a multi-threaded design method. The first is some drivers that match the hardware module, and then the writing of the system software. The transplantation of RT-thread real-time operating system makes the designed system architecture modularized, threaded and real-time, which not only guarantees the stability of the system, but also facilitates the expansion and improvement of functions. The hardware includes android mobile phone host computer and WFi module, and the software system includes WFi module transplantation OpenWrt system, loading camera driver, and mobile phone host computer client software development. The customer feces communicate with the lower computer through WFi, remotely control the movement of the tea service robot, and collect real-time video, temperature and humidity, PM2.5 index, smoke and flame alarm and other information and send it to the upper computer of the mobile phone.

2.3. The Structure Design of the Tea Service Robot

The tea service robot in this article is small and exquisite, with a length and width of about 11cm, which is convenient to carry and is also suitable for children to play and entertain. Taking into account the later modular development, two PCB boards are now superimposed, and the pin sockets are used to fix the connection between them. Integrate some of the most basic modules of home service robots, such as motor drive module, power management module, STM32F4 minimum system, obstacle avoidance sensor module. It also integrates some add-on modules, such as smoke, temperature and humidity, OLED modules, etc. If you need to add some modules later, you can add them on PCB2. Therefore, the tea service robot in this article has better scalability. The base of the tea service robot is composed of a white shell, two motors, and a rechargeable battery. The camera module is on the top, the camera below the camera is the WiFi module, the camera and the WiFi module are connected through USB, and the bottom is PCB2. The WiFi module communicates with each other through the serial port and the serial interface of PCB2. PCB2 integrates many addable modules, and then the bottom PCB1 is connected to PCB2 through pin sockets, and the bottom is the base of the tea service robot.

3. Design of Remote Control System

3.1. Get Sensor Data

Obtaining the angle of the tea service robot is the premise that the robot can be controlled. The MPU6050 attitude sensor used in this article mainly obtains the attitude angle of the tea service robot. Under normal circumstances, the original data from MPU6050 cannot be directly used as motion processing data. It needs to be filtered and fused to convert it into the required tilt angle. This data processing requires software programming, which is efficient and real-time. It's worse, this article uses a digital motion processor to process the data. MPU6050 embedded DMP can perform posture settlement after initialization, configuration and other tasks are completed. The tea service robot itself is an unstable but controllable system. As long as precise control methods are applied to it, a stable effect can be achieved. For the tea service robot, the tilt angle and tilt trend of the robot are the feedback links of the control system, and the processor controls the steering of the motor and the size of the control amount according to the feedback amount. It is relatively simple to control the balance of the tea service robot. It only needs to convert the tilt angle and tilt trend signal of the robot into the PWM signal of the driving motor. To control the forward and backward of the tea service robot is to control the speed of the robot, and the control of the speed of the robot is based on the balance control. Collect wheel data through the encoder to obtain the movement speed of the tea service robot, integrate the encoder data to obtain displacement information, and convert these two information into PWM signals that control the speed of the trolley. The steering difference is obtained through the data collected by the encoder, and the steering angle of the tea service robot is obtained through the angular velocity of the gyroscope, and these two information are converted into PWM signals for controlling the steering of the robot. The formulas used in the process of obtaining sensor data are:

$$\Delta\theta = \frac{\Delta S_i - \Delta S_r}{W} \tag{1}$$

3.2. The Overall Design of the Remote Control System

The remote control system of the tea service robot mainly realizes real-time video monitoring, sensor information collection and remote motion control. Usually, the remote control system is divided into three parts: the acquisition terminal, the server, and the mobile client. Among them, the collection terminal is the lower computer sensing unit of the tea service robot, the server is the WiFi module transplanted with the OpenWrt system, and the mobile phone client is the upper computer application. The remote control system needs to implement the following functions: (1) Use Android phones and WiFi modules to realize remote video monitoring. The real-time cheeks collected by the camera of the lower-level computer are encoded and transmitted to the mobile phone via the network, and the mobile phone is used to detect the family status. (2) Use android phones to control the movement of the tea service robot. (3) Display the real-time values detected by sensors such as temperature and humidity, PM2.5, smoke and flame of the current environment on the android phone. In the workflow of the remote control system, the module is transplanted to the OpenWrt system, and a driver program called mjpg-streamer is running on this system. You can freely load the USB camera, set the video frame rate, screen resolution, and the port number, parity, baud rate and other parameters. Then set up the WiFi module and the home router, make the WiFi module connect to the network, and map the domain name to the current address. Open the upper computer client program, enter the address, successfully connect to the monitoring interface, get the real-time video stream shot by the camera and the temperature, humidity, smoke, flame and other sensor information sent by the lower computer to display on the mobile phone screen, and through the mobile phone the arrow keys and the OK key control the movement of the tea service robot. The formulas used in the design of the remote control system are:

$$U(x,y)=\sum_{i=1}^{n}\left(\frac{k_1}{d_i}+\frac{k_2\cdot T\cdot v_m}{d_i^2}\right) \quad (2)$$

3.3. Software Design of Remote Control System

Linear layout and relative layout can be nested, and this method is used in the design of the control interface. First, the entire interface is first defined as a linear layout, a relative layout is first nested to define a function selection bar, and then a linear layout is nested, and then a relative layout is nested in this linear layout to complete the control buttons, temperature and humidity collection, the design of controls such as smoke and flame alarm. Because when debugging the program, using the virtual device will spend a lot of time on the start up of the virtual device. To save time, set the USB debugging mode on the phone to open, and you need to install the USB driver on the computer to ensure that the phone can be connected to the computer. Then set up debugging to use a USB device instead of an emulator, and then run the program. When the APP icon appears on the mobile phone interface, you can test whether the corresponding function can be realized on the mobile phone. After opening the client icon, the first thing you see is the welcome interface of the APP. This interface sets up a 2-second courtesy program, and then jumps to the main selection interface. In this interface, you can select settings or start button to enter different interfaces for operation. Press the setting button, this interface can mainly modify the video address, wireless control address, and slogan. Press the start button, the main functions are also implemented in this interface, there are three option boxes in the upper left corner, the first option box can choose whether to control WiFi or Bluetooth control, the third option box can be a video screenshot, and then save, you can click to view View the captured photos in the photo option box. The upper right corner is the detection of some sensor values, including temperature and humidity values, PM2.5 values, smoke and flame alarm information, etc.

4. Robot Test

4.1. Robot Response Speed Test

Table 1. Robot response speed test results

Responding speed	Number of times	Percentage
Very speed	11	55%
Faster speed	5	25%
General speed	3	15%
Slower speed	1	5%

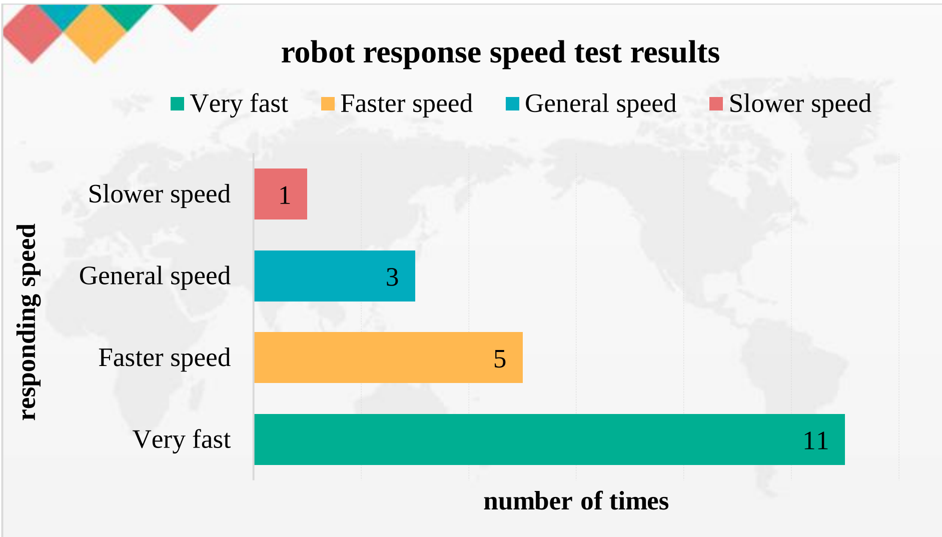

Figure 1. Robot response speed test results

According to Table 1 and Figure 1, it can be known that 20 response speed tests were performed on the robot. The results showed that 11 times were very fast, accounting for 55%. Five times were faster, accounting for 25%. There are 3 times the speed is average, accounting for 15%. One time was slower, accounting for 5%. On the whole, the robot has no problem in terms of response function, and the response speed is relatively fast.

4.2. Robot Human-computer Interaction Function Test

Table 2. Test results of robot human-computer interaction function

Interaction situation	Number of times	Percentage
Interact correctly	18	90%
Interaction error	1	5%
Unable to interact	1	5%

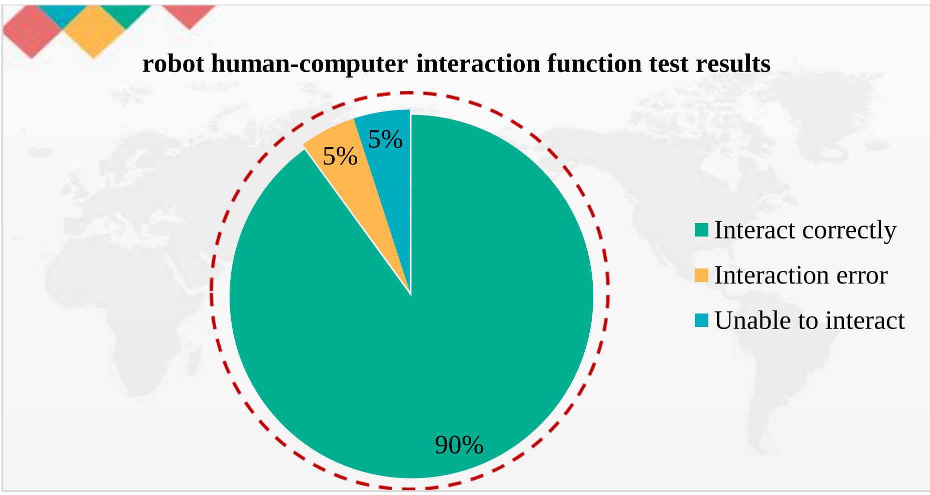

Figure 2. The test results of the robot's human-computer interaction function

According to Table 2 and Figure 2, it can be known that the human-computer interaction function of the robot is tested 20 times. The results showed that 18 interactions were correct, accounting for 90%. There was 1 interaction error, accounting for 5%. There was no interaction once, accounting for 5%. In-depth analysis of the reasons for the interaction error and the inability to interact, found that the inability to interact is caused by the exhaustion of the robot's power, and the interaction error is caused by a wiring error. After the wiring is adjusted, the interaction can be successfully performed. Therefore, the human-computer interaction function of the robot is very accurate.

5. Conclusion

Today, with the rapid development of embedded systems and Internet technologies, it is necessary to integrate these technologies to develop a cost-effective, small, and intelligent remote tea service robot system. In this paper, the lower computer makes full use of the advantages of the embedded processor's high performance, rich interfaces, and high reliability, and is transplanted with RT-thread real-time operating system to enhance the real-time and maintainability of the embedded system. The upper computer controller adopts an android smart phone with mature hardware and complete software architecture, communicates with the lower computer through WFi or Bluetooth, collects real-time video and sensor information of the lower computer, and can remotely control the movement of the lower computer. The remote tea service robot system developed in this paper can meet actual field applications in terms of performance, power consumption, volume, and can meet actual family needs in terms of cost performance, stability, and intelligence.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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