Design of an Intelligent Pet Feeding System Based on STM32

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Abstract

This design aims to develop an intelligent pet feeding system based on the STM32F103RCT6 microcontroller. By integrating multiple sensors and actuators, the system achieves automated feeding and watering, while also offering a user-friendly interactive interface and remote monitoring capabilities. This paper details the system's hardware and software design, implementation processes, functional testing, and result analysis. The system's stability and reliability have been verified through rigorous testing. Although there are areas for improvement in practical application, this design has achieved the basic functions of intelligent feeding and possesses good potential for expansion.

Keywords: STM32F103RCT6, intelligent pet feeding, sensors, user interaction, remote monitoring

1. Introduction

Nowadays, with the improvement of people's material living standards and the diversification of spiritual needs, the pet industry has been unprecedentedly developed.

However, with the acceleration of the pace of modern life, people's increasingly busy daily life has gradually transformed the affectionate care and proper care of pets at home into a topic that cannot be ignored[1].

The design and development of intelligent pet feeding systems provides an effective way to solve the above problems. Through the Internet and artificial intelligence, the system is designed with integrated sensors, timers and network interfaces, which can realize the function of caring for pets while fully taking into account the convenience and life rhythm of pet owners[2]. When pet owners need to go out for a long time, they can remotely control the feeding time and amount from their mobile device. In people's busy lives, the system can assist pet owners with feeding and watering, ensure that pets receive nutrition as planned, and provide appropriate and effective care for pets in a timely manner[3].

The design purpose of the intelligent pet feeding system is based on STM32F103RCT6 microcontroller, integrating a variety of sensors to realise the automatic completion of pet feeding and water supply tasks, and realise the function of interaction and remote monitoring through the support of host computer software to meet the needs of pet owners and pets[4].

The rest of this article is organized as follows. The second section introduces the hardware design of the system. In the third part, the software design of the system is introduced. In the fourth part, the results of the system tests and the analysis of the results are presented. The fifth part summarizes the main content of this paper.

2. Hardware Design

The design uses STM32F103RCT6 as the main control chip. As shown in Fig.1, in the intelligent pet feeding system, when the perception module of the system detects that the pet needs to eat, this information is transmitted to the control module for processing and analysis, and then the control module transmits the release instruction derived from the result analysis to the servo and the water pump of the execution module, so as to realise automatic water feeding. In addition, pet owners can feed through the LCD touch screen of the human-computer interaction module, and at the same time, they can also use the Bluetooth HC-05 module in the communication module to control the system through the host computer software for feeding. Fig.2 shows the actual system diagram.

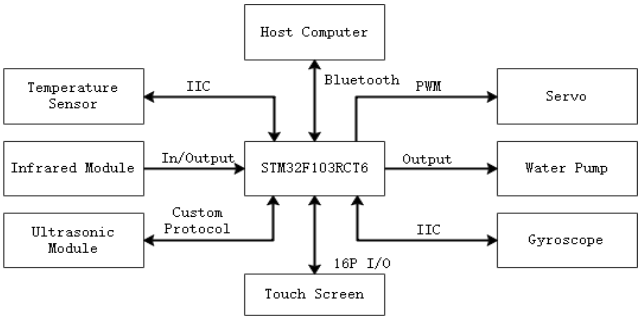

Fig.1 System control logic block diagram

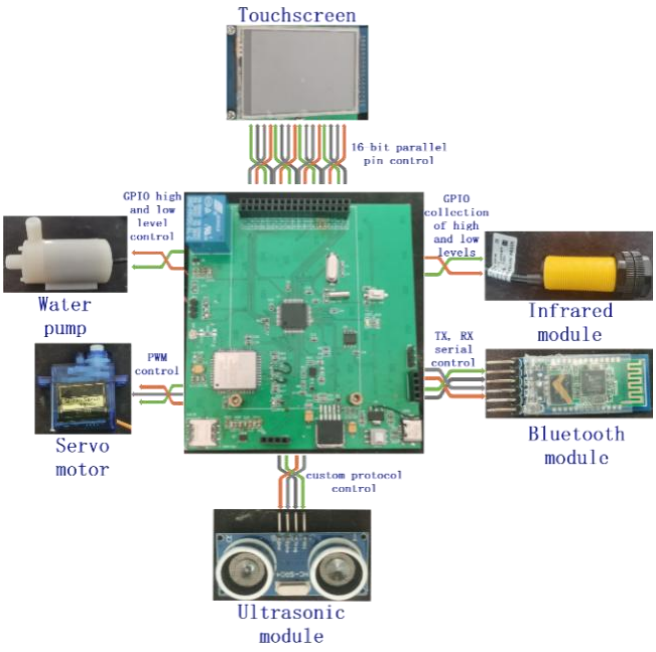

Fig.2 Physical diagram of the system

2.1. Main control chip

In this system, the STM32F103RCT6 microcontroller is used as the main control chip, as shown in Fig.3, which has powerful processing power, rich peripheral support and high cost-effectiveness, and has very high applicability in complex control and data processing tasks.

STM32F103RCT6 microcontroller has many functions in this system. First of all, the STM32F103RCT6 microcontroller has the function of information collection, which effectively communicates with various sensors through interfaces to collect the operating status of feeding and drinking mechanisms and environmental information in real time. In addition, based on data processing, the STM32F103RCT6 microcontroller can issue instructions to each actuator based on the analysis results, for example, send instructions to the servo and water pump, control the feeding and drinking of pets, and ensure timely response to pet needs. At the same time, the microcontroller is also linked with the host computer software to allow pet owners to remotely monitor the status of the system through the interactive platform to help pet owners understand the number of times their pets eat.

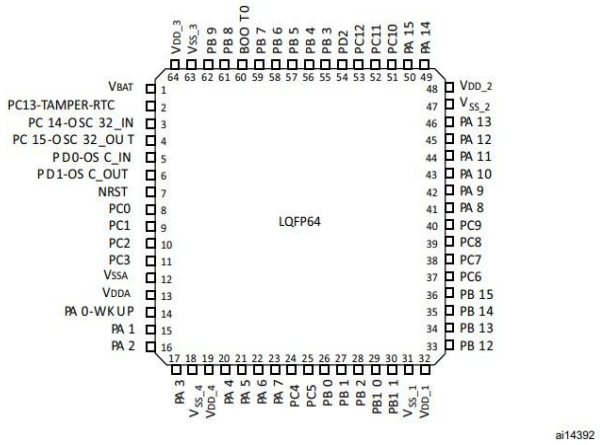

Fig.3 Pin diagram of the microcontroller

2.2. Sensor modules

The sensor module of the pet feeding system integrates an infrared sensor, an ultrasonic sensor, a gyroscope, and a temperature sensor to accurately detect and respond to pet behavior.

The infrared sensor, E18-D80NK, initially detects the pet's presence within a 70cm range, triggering the ultrasonic sensor, HC-SR04, to ensure precise distance measurement, activating the feeding mechanism only when the pet is at the optimal distance of 30cm. The gyroscope, MMA8452, monitors the system's stability, alerting the owner if the device is tipped or moved, thereby preventing feeding errors. Additionally, the TMP102 temperature sensor maintains optimal food storage conditions by monitoring ambient temperature, ensuring the pet's food remains fresh and consumable. Together, these sensors work in harmony to ensure efficient and safe operation of the feeding system, promoting the pet's health and the system's reliability.

2.3. Execution module

In this smart pet feeding system, the execution module includes a servo and a water pump, and the function of the module is to ensure that the system can carry out the instructions for feeding and water supply.

(1) The servo

When performing the feeding function, the servo can adjust the opening and closing of the feeder mouth according to the instructions of the control module, so as to accurately control the amount of food fed and the feeding time. The servos are able to respond quickly to commands in a short period of time, providing discrete or continuous feeding, allowing the system to meet the dietary needs of pets at different times.

The servo used in the system is the SG90, which is a miniature position servo drive. The working principle of SG90 is to accurately control the rotation angle by receiving control signals, which is widely used in model aircraft, robots and other fields.

(2) The water pump

The water pump is responsible for supplying the water required by the pet when performing the water feeding

function, and similar to the servo, the water pump also operates according to the instructions issued by the control module to ensure that the pet has a stable and hygienic water source.

2.4. The human-computer interaction module

The human-computer interaction module uses the LCD touch screen as an interactive platform, providing an intuitive and easy-to-operate interface for pet owners. The interface allows pet owners to easily set up various functions and customise a personalised feeding plan for their pet.

The interactive interface of the system uses a 2.8-inch resistive touch screen, which can be operated directly by pet owners. When the pet owner touches different areas of the screen, the resistance value of the screen changes to enable control of the system.

2.5. The communication module

The communication module used in the system is the Bluetooth HC-05 module, which has the function of wireless connection and data exchange with the user's smart devices (such as mobile phones or tablets).

In this system, the Bluetooth HC-05 module works in slave mode, and the STM32F103RCT6 microcontroller connects with the Bluetooth module through the UART communication protocol, so as to realise wireless communication with the mobile phone software. When the system performs feeding or water supply functions, the relevant data will be sent to the Bluetooth HC-05 module via the control module, and then transmitted to the communication device via Bluetooth. As a result, pet owners can monitor their pets' feeding and drinking conditions in real-time on communication devices. Through this communication module, the system realises the connection between the system and the communication equipment, and also greatly improves the user's operation experience and the convenience of the system.

2.6. Design of PCB boards

This smart pet feeding system is mainly used in home life, so the volume should not be too large. Therefore, in this system, we use 9*10 PCB boards for hardware design.

PCBs are designed to make circuits miniaturised, intuitive, and play an important role in the optimisation of electrical layouts. The design of the PCB board is shown in Fig.4.

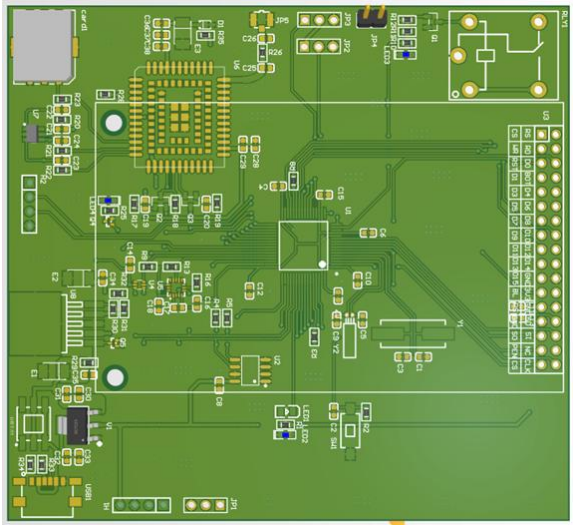

Fig.4 3D view of the PCB

3. Software Design

The software design of the system uses Keil 5 MDK version 5.37.

The total programme flow chart of the system is shown in Fig.5, through the software design, the system realises the functions of infrared/ultrasonic detection and feeding control, dumping detection and alarm, temperature monitoring and so on.

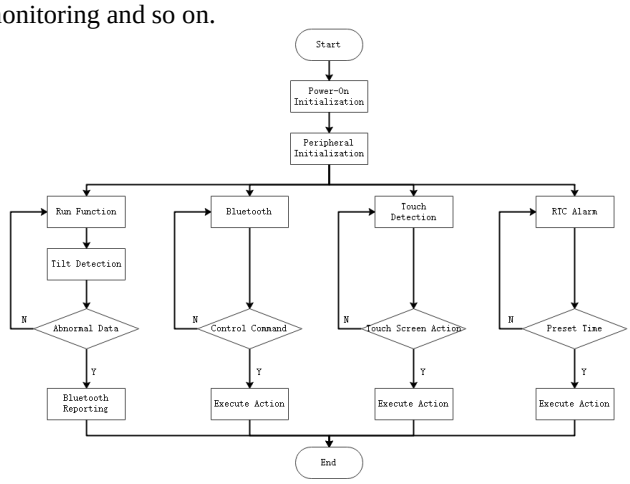

Fig.5 Overall software flow chart of the system

4. System Testing and Analysis of Results

In this design, the five core functions of the system (timed feeding, infrared/ultrasonic detection, tipping detection, temperature detection, and control and feedback of mobile app) are tested.

The experimental results show that the intelligent pet feeding system has basically realised the functions of automatic water feeding, ambient temperature monitoring, equipment tipping detection, Bluetooth control and so on.

4.1. Timing feeding function test

Table 1 records the test results of the timed feeding function. The data show that the deviation between the trigger time of the actual feeding and the preset time of the

system is within the acceptable error range, which proves the stability and reliability of the timed feeding function.

Table 1 Timing feeding function test results

Test number	Preset feeding times	Actual trigger time	Deviation	Outcome
01	08:00:00	08:00:02	+2s	Pass
02	12:00:00	12:00:04	+4s	Pass

4.2. *Infrared/Ultrasonic Detection Testing*

Table 2 records the test data of the infrared/ultrasonic detection function. The table shows that the system is able to accurately activate the feeding and feeding procedures when the infrared sensor detects an object within a set range of 70 cm and the ultrasonic sensor ensures that the object is within 30 cm of the feeding programme.

Table 2 Infrared/Ultrasonic test results

Test number	IR presets Detection distance	Ultrasound presets detection distance	Physical distance	Outcome
01	70 cm	30 cm	20 cm	Feeding
02	70 cm	30 cm	50 cm	Do not feed

4.3. *Tipping detection test*

Table 3 shows the performance of the tip detection function of the system. The test verifies that the system is able to detect and issue an alarm in time to prevent misoperation of the equipment in the event of a tipping event.

Table 3 Dump detection test results

Test number	Simulate the dumping angle	Test results	Whether or not to trigger an alert	Outcome
01	15°	Not detected	No	Not passed
02	45°	Detect	Yes	Pass

4.4. *Mobile device functionality testing*

When the serial port assistant of the mobile app is used to send WATER to the Bluetooth module, the device starts to run the pumping work, returns WATER when the command is received, and returns happen water when the action is executed, as shown in Fig.6.

Fig.6 Bluetooth water feeding function test

When the serial port assistant of the mobile app is used to send FEED to the Bluetooth module, the device starts to run the feeding work, returns OK when the command is received, and returns the happen feed when the action is executed, as shown in Fig.7.

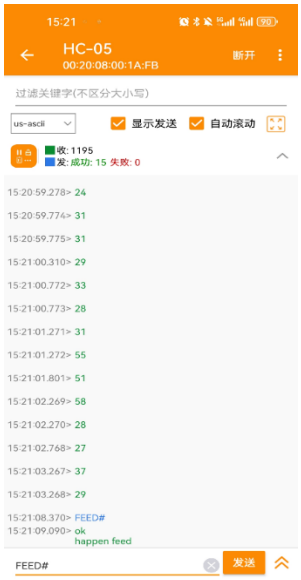

Fig.7 Bluetooth feeding function test

5. Conclusion

This paper presents the design and implementation of an intelligent pet feeding system utilizing the STM32F103RCT6 microcontroller. The system integrates various sensors and actuators to achieve automatic feeding and watering, while providing user-friendly interfaces and remote monitoring capabilities. The hardware design involves sensor modules, including infrared, ultrasonic, gyroscopic, and temperature sensors, to accurately detect and respond to pet behavior, ensuring efficient and safe operation. The execution module, consisting of a servo and water pump, executes feeding commands precisely. The

communication module facilitates remote control via Bluetooth, enhancing user convenience. Rigorous testing demonstrates the system's stability and reliability in key functions like timed feeding, detection accuracy, and mobile control. While there is room for improvement, the system successfully fulfills its primary functions and offers potential for future expansion, addressing pet care challenges in modern busy lifestyles.

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