Intelligent pet cat care residence design based on cloud platform

Tengfei Li [1, *], Haoran Zhang [2, #], Chunyan Fu [3, #], Linna Li [4, #]

[1] School of Mechanical and Electrical Engineering of HISI, Henan Institute of Science and Technology, Xinxiang, China, 453003

[2] School of Instrument Science and Optoelectronic Engineering, Hefei University of Technology, Hefei, China, 230009

[3] School of Information Engineering, Guangxi College of Water Resources and Electric Power, Nanning, 530023, China

[4] School of Physical Education, Nanyang Normal University, Nanyang, China, 473132

* Corresponding Author Email: litengfei171@gmail.com

[#]These authors contributed equally.

Abstract. In order to provide an intelligent living environment for pet cats, so that owners can understand and control the daily life of pet cats, and communicate and interact with them through voice, a remote pet cat care system was designed. The system uses a remote monitoring function that combines a cloud platform and a camera, allowing owners to keep an eye on their pet cats' movements even when they are away from home. This system uses PLC as the main control unit and STM32 single chip microcomputer as the slave, which can not only collect temperature, humidity, light intensity, pressure and other signals, but also carry out real-time control of the controllable hardware in the system, and transmit the collected data to the cloud platform. 4G communication technology is adopted, and users can remotely complete the intelligent control of all equipment in the system through the cloud platform. To realize real-time monitoring and interaction of pet cats in all aspects; According to the pet cat daily diet, drinking water, exercise and other important data to determine whether the physical health. This can improve the service level of the pet cage industry and inject technological power to make pet cages more intelligent.

Keywords: Pet Cat Care Home, Intelligent, cloud platform, real-time monitoring.

1. Introduction

With the economic growth and social development, people gradually attach importance to the enrichment of spiritual life, and pets can not only provide people with companionship to relieve people's mental pressure, but also enrich their spiritual life and relax their body and mind. Therefore, now more and more pets have become an important member of the family [1], and their owners take care and love them like children. However, on the one hand, due to the restrictions of transportation and accommodation in China, it is difficult for pets to go out with their owners during business trips or tours. On the other hand, because pets, work and leisure cannot be both, it is difficult to take care of every detail of the pet's daily life, pets can only be forced to foster, and in some pet foster shops, pet foster rooms will be placed in a corner without sunlight, placing several pet cages, you can receive foster pets. Foster according to the size of the pet, choose the cage, the foster pet cannot freely turn around and play, once the foster means to be taken back by the owner to obtain freedom, not only needs a small amount of money and cannot observe the dynamics of their favorite pet in real time, timely understanding of the situation of love pet, which has become the pain of most pet lovers.

In order to solve this pain point, our team researched and designed a remote pet cat care system [1-3], which combines cloud platform [4] and vision, and has a series of intelligent facilities for pet cats to play, rest, eat, etc. Pet cat owners can observe the status of pet cats at any time, and communicate with pets through voice. In this way, the owner can not only pay lower fees than the pet

foster shop during the work or travel, but also make the pet cat happier when the owner is away from home, and the owner is more at ease when leaving.

2. Overall product design

2.1. Overall system design

In order to provide intelligent living environment for pet cats, so that owners can understand and master the life of pet cats, and communicate and interact with them through voice, this product designs an intelligent pet cat care system based on cloud platform. The product is nested inside the user remote intelligent terminal, health monitoring and evaluation system, environmental monitoring system and pet cat cage intelligent equipment and other systems. The user's remote intelligent terminal is based on the cloud platform as the core and the 4G gateway [5] as the medium for operation and maintenance. Users can access the cloud platform through the network of mobile phones, tablets and PCS to control the operation of intelligent equipment inside the cage in real time, read the CPU time, data and data processing, and correct the controller time. Video surveillance of the entire interior of the residence is also available. In addition, users can learn about the pet cat's living environment, living habits and daily health status through the cloud platform. The health monitoring and evaluation system mainly collects the physiological health data of pet cats through the sensor. The CPU has a set of conclusions drawn from the experiment of multiple varieties of pet cats, and fits a set of proportional operations. Then the collected data is output in the form of percentage through this proportional operation to determine whether the pet cat is healthy. The environmental monitoring system is mainly composed of infrared adjustable lights, timed ultraviolet disinfection lights, intelligent ventilation devices and temperature and humidity detection and adjustment devices. When the pet cat is detected, the lights are turned on. When the pet cat rests or leaves, the lighting will be turned off to achieve the effect of energy saving and environmental protection. The CPU will turn on the ultraviolet disinfection lamp at a fixed time to completely eliminate the pet cat's home, so as to ensure that the pet cat has a comfortable, secure, clean and warm home. Intelligent ventilation device and temperature and humidity detection and regulation device are intelligent trigger, when the temperature is lower than 18℃, the CPU orders the heater to open for heating operation. When the temperature is higher than 25 ° C, the CPU starts the fan to cool down. When the relative humidity is lower than 30%, the CPU commands the humidifier to humidify the air. When the relative humidity is higher than 60%, the CPU starts the fan to desiccant the air. The overall system design diagram of our intelligent pet cat care home is shown in Figure 1.

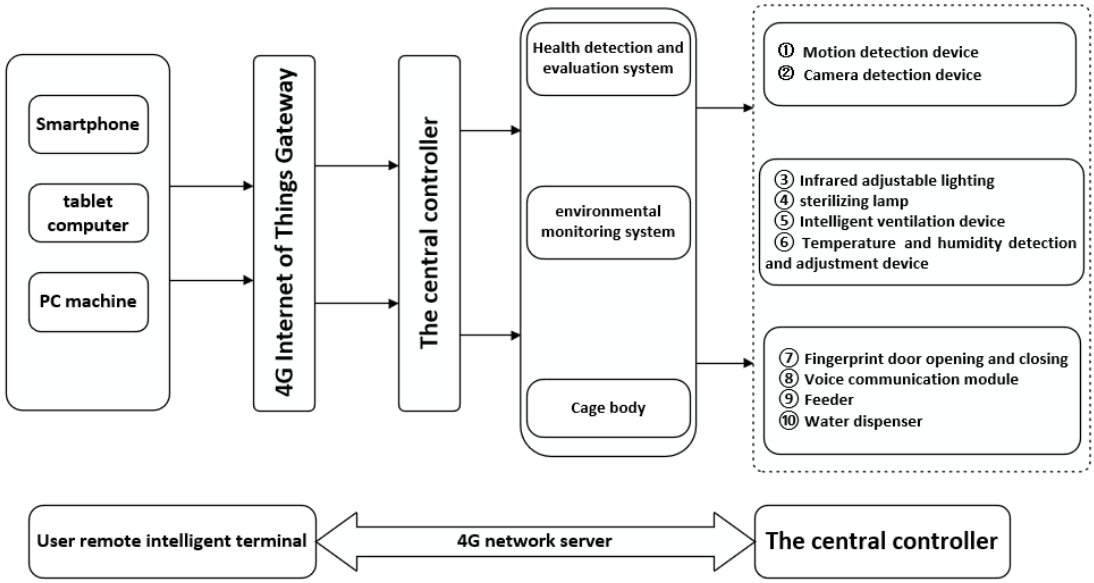


Figure 1. General design block diagram of intelligent pet cat care housing system.

2.2. Hardware design

Our intelligent pet cat care home is mainly composed of Siemens S7-1200 central controller, 4G gateway module monitoring, control camera module, STM32 microcontroller slave module, food module, password opening and closing module, heater module, humidifier module, sensor module nine parts. The functions of each module are as follows:

2.2.1. Siemens S7-1200 Central controller

This home uses Siemens S7-1200 transistor output type PLC as the central controller to process the data collected by the sensor, communicate with the cloud platform through ModbusTCP protocol and control most of the intelligent equipment inside the home while communicating with the slave computer to read data. The controller ensures easy system development, fast startup, precise monitoring and security, and acts as a bridge between the cloud and the execution end in your home.

2.2.2. 4G Gateway Module

In order to realize the remote control of the intelligent equipment inside the residence, 4G gateway is adopted as a mobile communication device to realize the remote information processing service [6]. 4G gateway module has a high data transmission rate and low transmission delay, which can meet the real-time application needs of remote control and video surveillance in this home. In addition, its network connection is stable, flexible and stable, coupled with the advantages of low cost, high security and reliability, making it a wide range of application prospects. Therefore, we use this module to communicate with PLC by Modbus TCP protocol. The 4G gateway can upload the data collected by the PLC through the sensor to the cloud, and the user can transmit the control signal sent by the cloud to the PLC, and then remotely control the internal intelligent equipment.

2.2.3. Monitoring Camera Module

The monitoring camera module in this residence is mainly to help the pet owner to view and take care of the pet cat remotely and in real time. The module is connected to the owner's personal terminal through the 4G gateway module, so that the owner can observe the situation of his pet cat anytime and anywhere to ensure the safety and health of the pet cat. During the observation period, the owner can also conduct remote real-time voice transmission with the pet cat through the voice exchange module, so as to interact with the pet cat.

2.2.4. STM32 MCU slave module

STM32 microcontroller from the machine module in this residence is mainly to collect and process the two environmental parameters of light and humidity, and the collected data will be transferred to the MCU processor for processing. After data analysis and processing, the processed signal is returned to the PLC central controller, and then uploaded to the cloud platform display, and the corresponding instructions are issued to the lighting system and ventilation system according to the incoming data of the sensor.

2.2.5. Diet module

The diet module is divided into two parts: drinking water device and feeding device [7].When the pet cat is detected near, the PLC will issue a command to start the drinking device, otherwise, the drinking device is idle. There are two working modes of feeding the cat food, automatic feeding and manual feeding. The automatic feeding mode is the default mode, and a fixed amount of cat food is fed regularly according to the eating habits of the pet cat every day. The artificial active feeding mode is that the owner observes the status of the pet cat and the remaining cat food in the tray through the monitoring camera, and then actively controls the feeding on the cloud platform.

2.2.6. Password opening and closing module

The main function of the password opening and closing module is that under the normal lock state, the number of unlocking is 4 times. After entering the correct password, press the confirm key to unlock. If you enter the wrong password for four consecutive times or enter the password for more

than 16 seconds, the buzzer will alarm and the password will be locked. In this case, you can only enter the administrator password to unlock the system. The electronic password lock also has the function of resetting and changing the password.

2.2.7. Heater Module

The heater module is used to ensure that the cattery is in a constant temperature range, in order to provide a comfortable and warm environment for pet cats. The heater is made of ceramic material, which can generate far infrared heat energy and has the characteristics of heating without luminescence. It can provide warmth to pet cats while also ensuring the sleep quality of pet cats without affecting the rest of pet cats. The heater temperature control mode adopts automatic temperature control, which can change the temperature by controlling the output power.

2.2.8. Humidifier Module

The humidifier module in this home is an ultrasonic atomizer, which uses triple water purification to release clean and high-quality spray mist to ensure that the interior of the home is in a constant humidity range.

2.2.9. Sensor Module

The sensor module mainly includes temperature and humidity sensor, pressure sensor and infrared thermal release sensor. The temperature and humidity sensor uses DHT11 module to collect humidity and temperature data. The pressure sensor adopts HX711 module to accurately measure the weight change of pet cats. The infrared thermal release sensor is controlled by HC-SR501 module.

2.3. Software Design

The software of remote pet cat care system is written by ladder diagram and C language, adopts modular design idea, and consists of main program design module, Modbus communication module, slave program module and cloud platform module.

2.3.1. Main program design

After the intelligent pet cat care home is powered on, the PLC will initialize the system, and the CPU mode will be switched from STOP mode to RUN mode. First of all, the CPU will scan and run the OB100 program block, and carry out the initialization operation self-check such as clearing DB data block and resetting each contact. Then start scanning to run the OB1 main block. The main program block contains FC functions such as feeding, drinking, playing, disinfection and data collection, health monitoring and evaluation. At this time, the central controller PLC communicates with the cloud platform and STM32 microcontroller slave module through ModbusTCP protocol to establish data connection. After completion, the important data in the PLC can be transferred to the cloud platform monitoring large screen page. Then, the control feeding device subroutine can be executed to first determine whether the CPU time is consistent with the local time, if not consistent, the controller time can be corrected on the cloud platform, and then the CPU will send a signal to start feeding at two fixed times. If you also want to feed the pet cat at these two time points, then the user can issue instructions on the cloud platform to complete the feeding operation of the PLC. Next, the drinking device trigger subroutine is executed, and when the pet cat is detected near the drinking tank, the PLC will issue an instruction to turn on the pump. At 20:00 every day, the CPU will collect the movement data of the pet cat today, and turn on the ultraviolet disinfection lamp. At 00:00 every day, the previous day's exercise data will be cleared, and the health monitoring function will measure whether the cat is healthy. Then the disinfection lamp will be turned off at 22:00, and the pet cat will rest in the house.STM32 MCU environment data will be obtained by reading STM32 slave computer environment data subroutine, every day all the data will be transmitted to the cloud platform in real time for display.

2.3.2. Control feeding device subroutine

First determine whether the CPU time is consistent with the local time, if not, the controller CPU time can be corrected on the correction time page of the cloud platform, and then the CPU will issue feeding instructions at 10:30 and 18:30 every day, and the feeding device will start to operate. Each time it is triggered, the CPU will trigger the counter to record once, and the data will be transmitted to the cloud platform in real time, and the user can watch the current diet status of the pet cat in real time on the diet interface. If you do not want to feed the pet cat at these two time points, then the user can directly issue instructions in the feeding interface of the cloud platform, and the PLC will repeat the above operations to complete the feeding action.

2.3.3. Drinking water device trigger subroutine

The effective input of the NPN type photoelectric switch is used as the trigger basis. When the pet cat appears in the water fountain 5 ~ 8cm, the photoelectric switch will be turned on, the PLC will issue the command to start the water pump and count it once, and the triggered timer will record the drinking time and transmit the number and time to the cloud platform in real time. If the pet cat is not in the detection range, the water pump will not work. When the water in the drinker is lower than the water level of the pump, even if the above trigger condition is reached, the pump will not work, and an alarm will be generated. After adding water, the pump will continue to work.

2.3.4. Pet cat daily exercise amount detection subroutine

Exercise testing is particularly important to measure the health of pet cats, which mainly measures the number and time of playing with toys. Take playing with a whack-a-mole toy as an example, when the pet cat presses the gopher claw in the whack-a-mole toy, the corresponding small gopher will emerge from the hole, the photoelectric switch can detect the gopher head and send the signal to the PLC, the PLC triggers the counter to increase the number of times, and at the same time, the timer is switched on for time accumulation. The time and number of daily plays will be transmitted to the entertainment interface of the cloud platform in real time for display, and the daily data will be cleared at 0 o 'clock local time, without manual initialization by the user.

2.3.5. Disinfection and health monitoring subroutine

Ultraviolet + ozone disinfection lamps are used to disinfect the interior of the home. The control mode is a timing switch, and the time elimination will be carried out from 20:00 to 22:00 every day.

2.3.6. Password Switch the gateway program

When the system is powered on and initialized, the initial state of the electromagnetic code lock is locked, at this time the door lock of the pet cat care system is locked, and at this time the system begins to read the data in the EEPROM to update the password. Then, when you want to open the door, enter the corresponding password. If the password is entered incorrectly, the MCU will not respond, and if the wrong input is 4 times, the system will alarm, and the unlocking system will enter the locked state. At this time, only the correct administrator password can be entered to unlock the system and carry out the basic operation of password opening and closing. Password opening and closing also has the function of changing the password. When you press the button to change the password, the system enters the stage of changing the password, then set a new password, and then press the Finish button to exit the stage of changing the password and enter the password interface again.

2.3.7. Modbus Communication Module

The system adopts ModbusTCP communication protocol [8]. The system uses PLC as the server and STM32 single-chip microcomputer as the client. The client sends messages to the server, which is processed by the server and uploaded to the cloud server to update data in real time. In the pet cat care system, the first connection is established, the single chip microcomputer as the client, through the TCP/IP protocol stack to the PLC server to initiate a connection request, establish a TCP connection. The MCU is connected to the IP address and port of the PLC to ensure that it can

communicate with the PLC. Once the connection is established, the microcontroller sends Modbus request commands to the PLC, such as reading the value of a register or writing data. The request command includes the slave address, function code, register address and data. PLC, as the ModbusTCP server, receives the request command sent by the single chip computer and carries out the corresponding data processing. At the same time, the cloud platform reads the data in the PLC register.

2.3.8. Slave program design

The slave program module is mainly composed of STM32 software program, which mainly includes sensor detection and processing module, Modbus communication module and password opening and closing module. First of all, the communication with PLC is established through the Modbus communication module, and then the process of temperature and humidity module subroutine and infrared module subroutine are executed, the collected environmental variables are processed back to the PLC, and the energy-saving lighting system and ventilation system are controlled.

2.3.9. Cloud Platform Module

First of all, the communication protocol and IP address are established on the PLC to communicate with the cloud platform. Then PLC initiates communication request to cloud platform through its communication module and uses ModbusTCP communication protocol to communicate. After the cloud platform receives the communication request initiated by the PLC, it identifies and analyzes it according to the configured protocol and address [9]. When the communication is successful, the data transfer will begin. When the system works normally, the pet cat's drinking water, diet, exercise, living environment parameters and other important data information and the monitoring screen in the residence will be transmitted to the cloud platform in real time, and the user can clearly understand the various life information of the pet cat. Users can also issue corresponding control instructions to the PLC through the cloud platform to achieve two-way communication and control.

3. Development and debugging

3.1. Development Process

S7-1200DC/DC/DC PLC plays the role of host in the development process, in order to reduce the development cost, reduce power consumption and save energy, STM32 MCU is used as the slave role. SBWZ series temperature transmitter, 4G gateway module monitor, control camera module, STM32 microcontroller module, food module, heater module, humidifier module, 57 stepper motor, UV disinfection lamp are all connected with PLC. LAD language is used on TIAPortalV17 to program PLC and control the above modules. Password opening and closing module, temperature and humidity sensor, pressure sensor and infrared thermal release sensor are connected with STM32 single chip microcomputer, and C language is used to program the single chip microcomputer in KeiluVision5.ModbusTCP communication protocol is used to connect PLC, microcontroller and cloud platform to achieve smooth transmission of data flow and command reception, and realize remote and timed quantitative feeding, health detection, periodic disinfection, environmental monitoring and regulation, password door, voice communication and interaction, video surveillance, intelligent drinking water and other functions. Our expected result is to continue to conduct in-depth research on health monitoring, to use deep learning to conduct real-time pathological analysis of pet cats [10-11], to inform the owner of the first time once the pathological analysis is found [12], and finally to comprehensively determine the health status of pet cats through visual pathological analysis combined with daily behavior detection.

3.2. Product Commissioning

3.2.1. Key methods are used for commissioning

In the debugging of this product prototype, our team chose to separate the software and hardware for separate debugging, and then combined the software and hardware to conduct the overall system test, that is, to check and debug the hardware circuit first, and then carry out the software modular debugging, and finally access the cloud platform for overall operation and maintenance debugging.

1) Hardware circuit debugging first, the circuit schematic diagram is drawn, and after the drawing is completed, the simple series and parallel fault inspection is carried out, as well as the simulation test of various voltages and currents. Then check the physical components to see if there is any damage.

2) Software simulation debugging the program writing platform equipped with the host controller and the slave controller is used for simulation debugging.

3) Integrated debugging of hardware and software is connected to the cloud platform to conduct overall debugging of the corresponding programs of each module circuit.

3.2.2. Debugging Process

In the process of hardware circuit debugging, our team first drew the electrical schematic, eliminated the circuit wiring problem in the circuit principle, and simulated the voltage and current of each circuit after drawing. Then, use the multimeter buzzer gear to determine whether the line is damaged, and determine whether most physical devices can be used normally. Then, after the line is loaded, power on, and detect the voltage and current of each channel through a multimeter. In the process of software simulation and debugging, we first simulate according to the connected circuit and write the program, and then observe the running state with the simulator to determine whether the simulation is consistent with the expected effect in the program. If not, the program will be adjusted until the adjustment is consistent. In the process of hardware and software combined debugging, after the separation of software and hardware is successful, we put China Garden Cat as the test object and access the cloud platform for software and hardware comprehensive debugging.

3.3. Analysis of experimental data

After the completion of the physical production, the Chinese garden cat was put into the residence, and a large number of tests were carried out from October 19 to November 1, and the residence was improved and upgraded. The living conditions of pet cats were monitored, and the monitoring indicators mainly included the number and time of drinking water, the number and time of eating, and the number and time of entertainment. The following is part of our test data, as shown in Figure 2 and Figure 3.

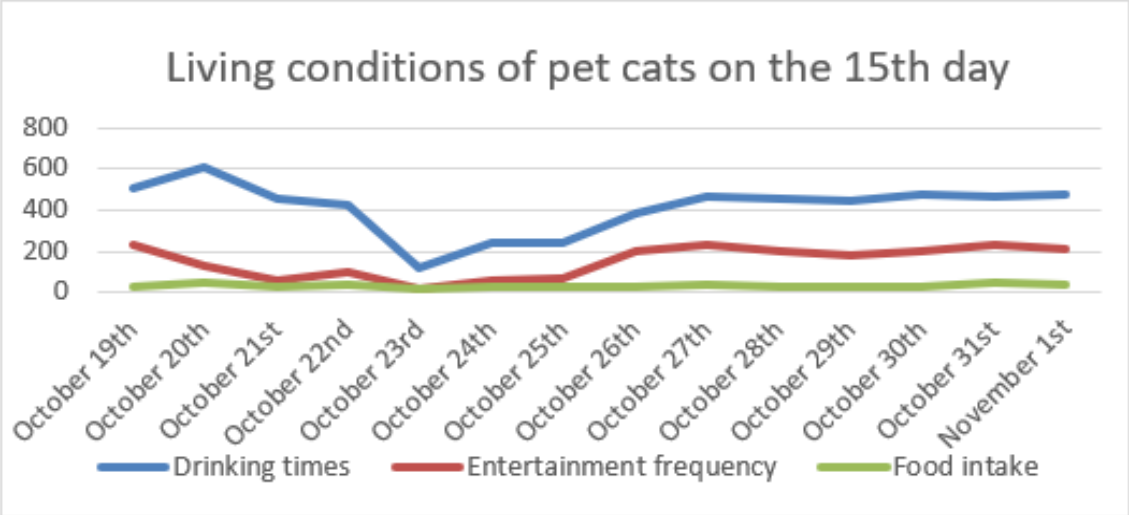


Figure 2. Living conditions of pet cats on the 15th day.

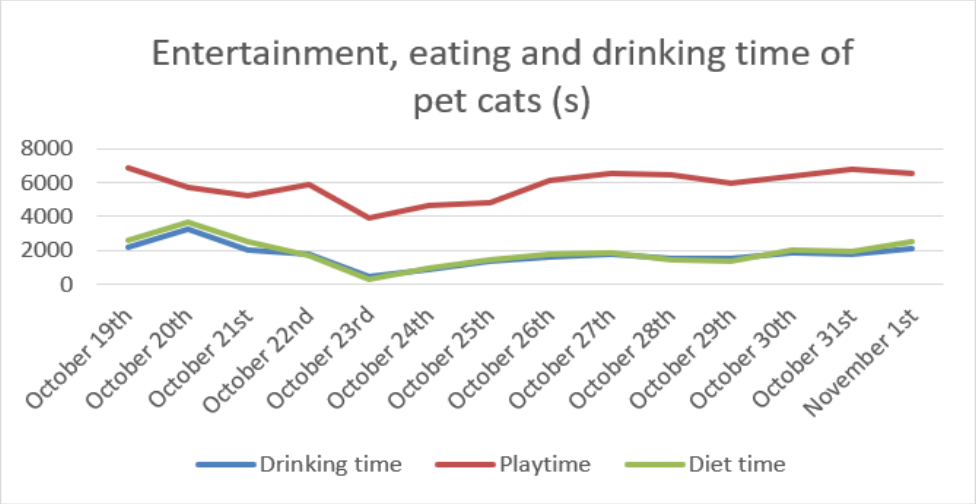


Figure 3. Entertainment, eating and drinking time of pet cats (s).

Through the analysis of the living conditions of the pet cat on the 15th day in Figure 2 and the entertainment, eating and drinking time (s) of the pet cat in Figure 3, it can be clearly seen that from October 23 to October 25, the exercise, eating and drinking time of the pet cat were at a poor level, and the pet cat was also in a pathological state during these three days. This further proves the reliability and stability of our health monitoring system. Through the data analysis of the pet cat's exercise, diet and drinking water, as well as watching the surveillance video, it can be seen that the pet cat has gradually returned to normal status after October 27. This has already achieved the purpose of making the care home at the beginning. In addition, after testing three different breeds of pet cats, we can conclude that any pet cat entering this home will not damage the home, and can adapt to the environment of the home in 3-5 days, and carry on a normal life.

4. Conclusions

Through a large number of experiments on different breeds of pet cats, we mainly collected data such as the amount of exercise, diet and drinking water of pet cats for comprehensive analysis. By comparing the collected data with the monitored behavior state, it can be obtained that the collected data and the data processing results are correct and effective, which proves that the intelligent care system of the product is feasible and reliable. And the internal intelligent devices are controllable low-power devices, using intermittent control mode to achieve the effect of low carbon energy saving. Therefore, the intelligent pet cat care residence based on the cloud platform can provide good comfort and safety, can ensure the health and happiness of pet cats living indoors, and can realize remote monitoring, feeding and other functions. It is convenient for users to manage and take care of pet cats, and can realize the monitoring of the environment and the health status of pet cats through intelligent equipment and sensors, which can timely detect the abnormal situation of pet cats and improve the care efficiency of pet cats. In summary, the intelligent pet cat care home based on the cloud platform is an innovative product that can meet the needs of pet cats and users. Through continuous optimization and function expansion, the intelligent home can better meet the needs of pet cats and users for quality of life. The application prospect of intelligent pet cat care residence based on cloud platform is very broad, and it has great development potential in the pet market. With the increasing attention to pet welfare and quality of life, intelligent pet cat care residence can provide cat owners with more convenient and intelligent pet cat management and care services. The innovations of our products are as follows:

1) Intelligent feeding system: The intelligent cattery system can automatically provide suitable food for the pet cat according to the feeding time and amount of food for the pet cat, and can also enable the cat owner to remotely feed and record the meal situation, helping the owner to better understand the eating habits and health status of the pet cat.

2) Novel health monitoring system: Comprehensively evaluate the health status of pet cats according to various factors such as diet, interaction, fecal volume and exercise amount.

3) Smart pet cat toys: The smart cat house system can set a time or automatically open a variety of pet cat toys according to the changes in the activity of the pet cat, enriching the activities and entertainment of the pet cat, and reducing the care burden of the owner.

4) Remote interaction function: The smart cattery system can realize remote interaction between the owner and the pet cat through the mobile phone mini program or other smart devices, such as video surveillance, voice dialogue, etc., so that the owner can pay attention to the situation of the pet cat and interact with it anytime and anywhere.

5) Intelligent cleaning system: The intelligent cattery system can be equipped with ultraviolet + ozone disinfection lights for regular elimination, reducing the workload of the owner to eliminate the cattery, and keeping the cattery clean and tidy.

As more and more people like to keep cats, and the health and quality of life requirements of pet cats are becoming higher and higher, the application prospect of intelligent cattery system is very wide. All in all, the intelligent pet cat care home has great development potential and will get more market recognition and development opportunities. At the same time, with the continuous development of science and technology, the function of the intelligent cat house system will be gradually enhanced and improved, providing cat owners with more convenient and comfortable pet cat rearing experience, and satisfying people's continuous pursuit of pet quality of life.

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