Design of Animal Detector Based on Thermal Imaging Sensor

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Abstract: Wandering in the city of stray animals to the life of urban residents, sanitation, safety, etc., bring a lot of trouble and become a thorny problem in urban management. In order to facilitate the search and rescue of stray animals by animal protection organizations, a low-cost animal detection system based on infrared thermal imaging technology was designed in this paper. Based on the infrared thermal imaging technology, the system adopts the Atmega328 microcontroller as the control core, and uses the infrared array sensor to detect the external infrared radiation and converts the voltage fluctuations caused by the thermal radiation into digital signals through the built-in ADC. The master control converts pseudo color images through SPI bus, and interacts with the system through ESP8266 to achieve the temperature information collected by AMG8833, controls the color LCD to display infrared pieve remote control. The infrared detection system has the advantages of small size, low power consumption, low cost, wireless communication and portability. It can realize the search and rescue of small animals in urban areas and the monitoring function of indoor animals.

1. Introduction

At present, the number of domestic dogs in China is about 150 million, and the number of domestic cats is between 50 million and 60 million [1]. The large number of pets raises the problem of stray animals caused by complex reasons such as city management, owner relocation and deliberate abandonment. They sleep on the street and affect the urban ecological environment. Due to the harsh living environment, most of them carry bacteria and parasites, which bring extra burden to the urban sanitation work. In addition, stray animals running around may affect traffic and cause potential danger to drivers [2-3].

At present, the management, rescue and search of stray animals mainly rely on human resources, but some stray animals will hide in crevices of buildings, hidden caves, and debris piles in blind corners that are difficult for human eyes to observe, bringing difficulties to the search and rescue work. Life-saving instruments, often used in search and rescue sites, can solve this problem, but they are expensive. Considering the funding and manpower of stray animal protection organizations, it is of certain social significance to design a low-cost, miniaturized animal search and rescue equipment.

The existing radar-type detectors, gas-type detectors and acoustic wave vibration detectors do not meet the requirements of this paper, because radar-type detectors have high cost and limited volume. The gas-type detector is not suitable for searching in the open area, and the search speed is slow, the technology is not very mature; although the cost of acoustic vibration is low, because it is based on sound wave to detect, it is easily disturbed by noise, and the result display is not intuitive.

This paper mainly USES the Atmega328 microcontroller and AMG8833 infrared array sensor to design the animal rescue instrument, and can display the processed infrared pseudo-colour image on...
the LCD, and can realize remote control and monitoring through the Wi-Fi module, and display the monitoring information in the APP of the smartphone client.

2. Working principle of infrared thermal imager

Infrared thermal imager, also known as thermal imager or thermal imager, is a kind of equipment for imaging the infrared light emitted by objects, which is widely used in military, fire, medical, industrial production, customs inspection and other fields.

Infrared thermal imager has two different principles: photon detection and thermal detection. The former mainly uses the electrical effect generated by photons on semiconductor materials for imaging, which is highly sensitive. However, the temperature of the detector itself will affect the detection accuracy, so the cooling system is required. The latter, which converts heat from light into electrical signals, is less sensitive but does not require a built-in cooling system. In addition, it is also classified according to the operating band of the thermal imager and the photosensitive materials used. Common thermal imagers work from 3µm to 5µm or 8µm to 12µm, and commonly used photographic materials are lead sulfide, lead selenide, indium telluride, tin telluride, mercury telluride, cadmium telluride, and doped germanium and silicon. According to the number and movement mode of sensor, there are mechanical scanning and staring imaging [4].

Type uncooled infrared thermal imager working principle is the infrared radiation energy will be issued an object through the infrared optical lens focused on the infrared detectors, infrared detector through photoelectric conversion and send information to the electronic components, main control unit for image processing, makes the data from the detector can be translated into in the viewfinder or standard video monitor or LCD screen to view images, namely the eye visible infrared images. It works by receiving the infrared radiation of the target itself without any interference to other precision electronic instruments. The components of infrared thermal imager generally include: infrared lens (B), infrared detector (C), processing circuit (D), display circuit (E), etc. The basic structure is as shown in figure 1.

![Figure 1. The schematic diagram of infrared thermal imaging](image)

3. Hardware design of infrared detection system

3.1 Overall scheme design of the system

This paper adopts Atmega328 AVR micro controller as the master control system, the kernel using infrared sensor array AMG8833 to test the external infrared radiation, with built-in ADC converts voltage fluctuation caused by thermal radiation into digital signal, and the master data to communicate via I^2C agreement, the master will be transformed from AMG8833 temperature information, through the SPI bus control colour infrared pseudo colour image displayed on the LCD, ESP8266 interact with the system through UART to realize the remote control. The hardware system scheme is shown in figure 2.
Choose Atmega328 as reasons of the master control system are: it is a low power consumption based on the structure of the AVR enhanced RISC 8-bit microcontroller, in the late 328p further reduces the power consumption, thereby reducing the power consumption of the whole system, its built-in flash memory read/write 32 KB ISP, block 1 KB EEPROM, 2 KB SRAM, article 23 general-purpose I/O lines, 32 general-purpose working registers and serial programmable USART, rich peripherals, less than eight traditional 51 microcontroller can outside enlarge a bunch of additional chip, reduce the circuit complexity, and overall cost.

3.2 Circuit design of infrared detector

The most important basic requirement for infrared thermal imaging is the selection of infrared detector, which has a great impact on the whole thermal imaging system. For example, the performance of the camera is not only limited by the optical system before imaging, but also limited by the performance of the imaging sensor. The characteristics of the mid-infrared detector in this design will affect the whole system.

The infrared sensor in this paper adopts panasonic grid-eye AMG88 series AMG8833. AMG8833 is the 3.3v high-gain version of this series, and the measured temperature range is 0-80℃.

Because this kind of sensor and MCU is communication mode of I2C, and the I2C communication because it USES only two data line SDA (cable), SCL (the clock line), MCU data synchronization transmission before the first byte is from the machine address (top seven said device I2C address, eighth said the direction of the data transmission, the sending or receiving), after receiving from the response signal of machine (ACK), to start the I2C bus and data synchronization [5], so the need to set the sensor I2C address right to work, according to the manufacturer to design reference manual, Figure 3 circuit principle diagram for sensor module, include 5 V to 3.3 V circuit, I2C level conversion circuit and connect the power supply and micro controller with convenient socket JP1, the sensor I2C address is 1101001 (0 x69), INT for sensor pin interrupts, and Arduino UNO external interrupt the I/O ports to connect (connected with the Arduino D2 or D3, corresponding to the Arduino UNO external interrupt int0 or int1), when the interrupt function of active sensor, when sensors detect any hot spots in setting temperature, The interrupt signal is triggered and sent to the MCU for action.
3.3 LCD display circuit design

The LCD display USES a color LCD based on the Sitronix ST7735 controller, which supports up to 260,000 colors, can use SPI or 8-bit / 9-bit / 16-bit or even 18-bit parallel input control, and supports up to 132X162 pixels. This paper adopts a 1.8-inch 160X128 pixel color LCD screen module, which is controlled by SPI bus [6]. The interface and part of the backlight circuit are shown in figure 4.

![Schematic diagram of LCD display circuit design](image1)

**Figure 3.** The schematic circuit diagram of infrared detector module

**Figure 4.** The schematic diagram of LCD module pin and backlight circuit

This design USES the Arduino UNO hardware SPI interface (D13 for SCK, D11 MOSI access SDA), although the Arduino UNO support soft simulation SPI, but the hardware SPI control speed is much faster, and can reduce system resource usage, the D10 as LCD screen choose enabled, D9 for LCD reset signal, D8 access provide data command control signals for LCD screen, backlight connected to VCC achieve backlight normally on the screen.

3.4 Design of Wi-Fi communication module

In order to realize the remote control function of the microcontroller, this design adopts an independent communication control module based on Wi-Fi technology to communicate and interact through the UART of Arduino UNO.

The design USES a highly integrated Wi-Fi SOC (system on chip) solution, the ESP8266 series. It is a low-power compact integrated system with complete and self-contained Wi-Fi network functions, which can be applied independently or carried on other MCU hosts. When ESP8266 is standalone, it is able to boot directly from flash. The built-in cache improves system performance and optimizes the storage system. In addition, ESP8266EX can be used as a Wi-Fi adapter through either the SPI/SDIO interface or the I²C/UIART for remote network control in any microcontroller-based design [7].
Based on the excellent properties of SOC and performance will be secondary development, many vendors based on its different communication control module, the internal integrated their own software and control command, this design uses the ESP8266 module with built-in Gizwits' firmware, the firmware can let ESP8266 connect to a remote server response operation, the user through the UART interface module can easily realize communicate with different MCU to realize the remote control. With Arduino UNO only need TXD-RXD, RXD-TXD, the power can be. Figure 5 is the circuit schematic diagram of the module.

Figure 5. The circuit diagram of Wi-Fi communication module

4. Software design of infrared detection system

The main work of the system software is to control the infrared sensor by the micro-controller and process the data returned by the infrared sensor. After the processing, the display screen is controlled to display the corresponding content. During the process, the communication is conducted with the Wi-Fi communication module, and the content is the configuration information related to the infrared sensor. The main part of the software design includes the self-test after the system is just powered on, mainly to check the working state of the infrared sensor, the initialization of the Wi-Fi communication module, and the startup of the infrared pseudo-color image display after the self-test. When the external interruption is caused by the infrared sensor, the Wi-Fi communication module will communicate and report the trigger information.

4.1 System initialization

The system initializer part is in the void setup () of the Arduino program code. This part of the code executes only once after the system is powered on, unless the system is reset unexpectedly. The initialization part of the system includes Arduino I/O working mode, UART port configuration, LCD module initialization, Wi-Fi communication module initialization and finally infrared sensor port initialization. D3 is the external interrupt input, LCD initialization is mainly to set the display area and color control test, refer to the external library and hardware manual to set the size of the LCD screen, the correct display direction, otherwise abnormal display may occur. The Wi-Fi communication module initializes by referring to Gizwits' suggestion to set the working mode and related parameters of the connection network, and set the baud rate of the master UART communication correctly [8]. The flow chart of system initialization is shown in figure 6.
4.2 Infrared image display
This system is the most important part of the infrared sensor to receive the converted digital signal (after transformation temperature of each detection point information, as shown in figure 8, the test room temperature is 23.25°C), after dealing with the system master can be displayed on LCD and the visual images, and colour LCD display control need to write the colour control information display area, so you need to both data connection, can realize the infrared pseudo colour image display.

First shows the implementation of the process for each frame of the temperature information from the sensor, a new 8 * 8 colour temperature to the scale, through the map () function of the Arduino language will temperature information (the default setting range is 24-35°C) is mapped to a preset a LCD colour from blue to red control to scale, can use the blue colour to red after get the connect represent different temperature difference to the scale, written to the screen through the SPI bus controller, this completes a frame drawing[9]. Figure 7 is an infrared pseudo-colour image of a hot region obtained by a sensor. The closer the color of a certain region is to red, the higher the detected temperature is, and the bluer it is anyway.

5. Conclusion
In order to realize animal detection and rescue, this paper USES the Atmega328P microcontroller as the main control system, combined with the AMG8833 infrared array sensor, to design an animal rescue system. Firstly, the significance and current status of animal search and rescue research are introduced. Then, the theoretical basis of infrared imaging system is introduced, including the structure and working principle of infrared detector and AMG8833 infrared array sensor. Next, the
composition of the hardware system designed in this paper is introduced. Finally, the design of the system software is introduced.

Reference
[1] Lin D.G.(2010) Current situation, opportunities and challenges of China's pet industry .Chinese journal of comparative medicine, 20(Z1):13-16.
[2] Chen M.Y. (2016) On the ethical review and management of urban stray animals. Management observation. 29 : 75-77 + 80.
[3] Zhang S.Y.(2007) Feasibility analysis of TNR method to control the number of stray cats .Journal of veterinary medicine, 122(10):52-54.
[4] Yang L, Yang Z.(2012) Principles and techniques of temperature measurement in infrared thermal imaging .Science press, Beijing
[5] Li W, Hu Q.(2008) Life Detection, Experiment Methodology, Infrared Image and Spectrum Analysis Key Engineering Materials. Infrared Phys, 365-368.
[6] Li Q, Wu J.J, Liang Y.M, Song N.L, Deng Y. (2011) Data fusion technology based on infrared array sensor .24(4): 548-553.
[7] Bian E.T.(2015) Vehicle-mounted night vision system based on infrared thermal imaging .South China university of technology
[8] Chen L.Z.(2014) Arduino programming basics . Beijing University of aeronautics and astronautics press, Beijing
[9] Gade, Rikke; Moeslund, Thomas B. (2014) Thermal Cameras and Applications. Machine Vision and Applications 25:245-262