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DESIGN THERMAL CAMERA NON-CONTACT

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Abstract:

Thermal cameras are useful devices that are used in many different situations, such as quality control, system maintenance, structural repair, security, medical, monitoring, treatment. and diagnose human health or to research and develop advanced technological components. It provides visual temperature information that cannot be perceived by the human senses. Products from the research results of the author group towards compact size, easy to handle, convenient to carry, low cost of implementation, monitoring range in the measuring area of the sensor eye up to 7 meters. , the monitoring temperature zone can be limited, the color displayed is equivalent to the temperature zone, and the resolution of the thermal pixels can also be adjusted simply through the buttons. With basic functions that can be used such as non-contact body temperature measurement, maintenance, maintenance, quality inspection and repair of electronic, electromechanical, telephone, chip, IC, over temperature detection. Electrical system lines, underground cables, recessed walls, utilities, gas leak detection, ventilation furnaces, fireplaces, etc., the device can be a useful and effective civil tool.

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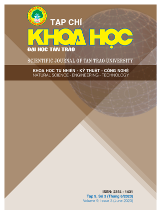

THIẾT KẾ CAMERA NHIỆT KHÔNG TIẾP XÚC

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Máy ảnh nhiệt, Camera nhiệt cầm tay, Đo nhiệt độ, Nhiệt hồng ngoại, Đo thân nhiệt không tiếp xúc.

Tóm tắt

Camera nhiệt hay máy ảnh nhiệt là thiết bị hữu ích được ứng dụng trong nhiều trường hợp khác nhau, như kiểm định chất lượng, bảo dưỡng hệ thống, sửa chữa các kết cấu, trong an ninh, y tế, theo dõi, điều trị và chẩn đoán sức khoẻ con người hay để nghiên cứu, phát triển các thành phần công nghệ tiên tiến. Nó cung cấp thông tin về hình ảnh nhiệt độ mà không thể cảm nhận được bằng các giác quan của con người. Sản phẩm từ kết quả nghiên cứu của nhóm tác giả hướng tới có kích thước nhỏ gọn, vừa tay cầm, thuận lợi mang theo, có chi phí thực hiện thấp, phạm vi giám sát trong vùng đo của mắt cảm biến lên đến 7 mét, có thể giới hạn vùng nhiệt độ giám sát, màu sắc hiện thị tương đương với vùng nhiệt độ, và độ phân giải của điểm ảnh nhiệt cũng có thể điều chỉnh đơn giản qua các nút bấm. Với tính năng cơ bản có thể sử dụng như đo thân nhiệt người không tiếp xúc, bảo trì, bảo dưỡng, kiểm tra chất lượng và sửa chữa các thiết bị điện tử, cơ điện, điện thoại, chip, IC, dò quá nhiệt đường dây hệ thống điện, cable ngầm, âm tường, điện nước, phát hiện đường ống rò rỉ khí gas, lò thông gió, lò sưởi, v.v, thiết bị có thể là một công cụ dân dụng hữu ích và hiệu quả.

1. Introduction

Temperature is a physical quantity that affects the properties and structure of all materials, and impacts the growth and development of plants, animals, and humans. To measure temperature, a thermometer can be used, and in addition, an infrared thermal camera can also be used. Thermal cameras work by capturing the infrared radiation emitted from an object to create an image that is described by colors corresponding to the temperature values at that point. The remarkable feature of thermal cameras is that they can capture images and temperatures in the light spectrum that human eyes cannot see. Therefore, their applications are diverse, spanning across many fields such as security monitoring, fire detection, medical applications, remote temperature measurement of people, maintenance, inspection, repair, warning of thermal, electrical, and electronic devices, etc.

To monitor, measure, and capture temperature regions, there are many thermal camera products available on the market from reputable suppliers. Examples of such products include Testo 868 from Germany with a resolution of 19200 pixels, measuring range from 30° to 650°C; Luke PTI120 which can measure from -20°C to 150°C with 10800 pixels; Fluke TIS20+ with a measuring range of -20°C to 150°C and 76800 pixels; CA 1954 with a monitoring range of -20°C to +250°C and 19200 pixels; FLIR E5-XT with a measuring range of -20°C to 400°C and 19200 pixels, etc. [1] Common features of these commercial products include various functions, resolution, accuracy, design, application range, etc. However, their prices are often too high and not suitable for individual research, widespread use in civil society, and they cannot be reconfigured and programmed by developers due to copyright and locked chips. In addition, researchers have proposed many studies on the application of thermal cameras, such as low-resolution thermal image calibration for human body temperature monitoring applications [1], a system for detecting motion using artificial intelligence based on thermal images that provide a measure of urinary flow to evaluate the severity of urinary tract disorders [2], non-contact body temperature measurement using deep learning in varying environmental conditions [3], real-time detection of electrical system faults based on thermal images [4], gesture recognition using thermal images and neural networks [5], developing thermal-infrared imaging detectors for testing electrical devices [6], using thermal cameras for detecting plant diseases [7], etc.

Recognizing the importance of temperature as well as the applicability of thermal cameras, the authors have conducted research and developed a compact device for monitoring temperature and collecting corresponding thermal images. The product is designed with low cost and can be reprogrammed for modification, upgrade, and adjustment according to the desired objectives.

2. System design

2.1. Hardware design

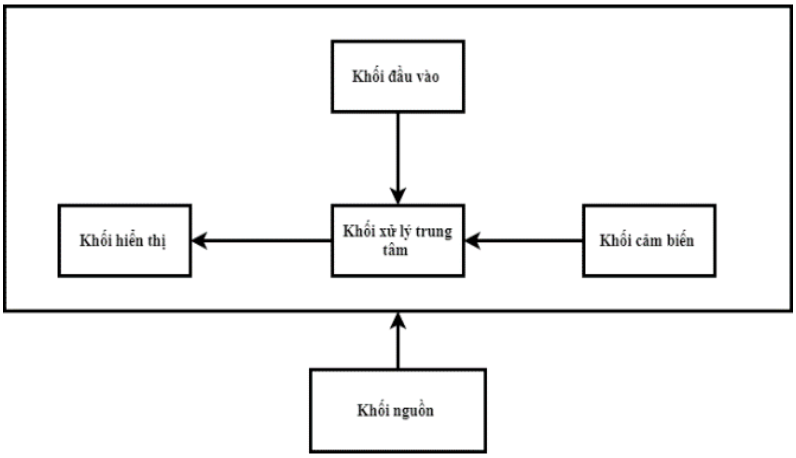


Figure 1. Block diagram of the handheld mini thermal camera system

The device is built according to the block diagram shown in Figure 1, which has the function of measuring infrared temperature without contact. The device displays the obtained values and corresponding color zones representing the areas with the highest temperature in white light, the average temperature in orange and yellow, and the lowest temperature in blue or purple.

Input block: This block consists of a switch, as shown in Figure 2(a), to turn the power supply on and off. The switch has a contact resistance of ≤ 20 MΩ and insulation resistance of ≥ 100MΩ. The block also includes buttons for device settings, as shown in Figure 2(b). These are PBS-110 type, normally closed (NC), with a power rating of 250V1A AC, and a resistance of 100 M.

(a) *(b)* *(c)* *(d)*

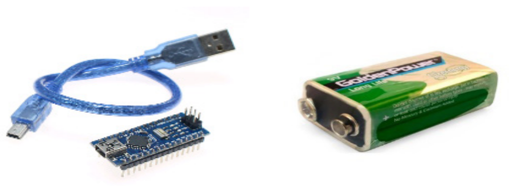
Figure 2. (a) Power switch; (b) Buttons; (c) OLED display; (d) AMG8833 sensor

- Display block: The device displays the parameters on a 0.95-inch OLED screen [8], as shown in Figure 2(c), with a resolution of 96 x 64, 65536 colors, SPI interface, and a voltage range of 3.3V to 5V.

- Sensor block: The device uses the AMG883 infrared thermal sensor [9], as shown in Figure 2(d), with a temperature range of 0°C to 80°C, an accuracy of ±2.5°C, a power supply voltage range of 3.3V to 5V, a maximum frame rate of 10Hz, and I2C communication.

- Central processing unit (CPU) block: The device uses an Arduino Nano board [10] as shown in Figure 3 (a) with an AVR ATmega328P-AU MCU core, which supports digital and analog I/O signals, UART, SPI, I2C communication, and can be restructured and programmed through the Arduino IDE.

- Power block: Provides DC power to the system, which can be supplied by a 9V battery as shown in Figure 3 (b) or a 3.3V ÷ 9V adapter.



(a) *(b)*

Figure 3. (a) Power switch; (b) Push button; (c) OLED screen; (d) AMG883 sensor.

2.2. Software program design

The thermal imaging camera device is designed as an algorithm that repeats infinitely, consisting of the following steps:

- Step 1: To start the program, libraries such as SPI, Wire, AMG8833, I2C need to be declared.

- Step 2: Declare the pre-processing: create connections between Arduino Nano and peripherals such as buttons, screens, AMG88 sensors, set the minimum temperature threshold tmin and maximum temperature threshold tmax to display notifications, define the color codes to be displayed on the OLED.

- Step 3: Check the conditions for setting the pixel value (via button 1), if:

- Correct: Increase the pixel value using button 1, decrease the pixel value using button 2.

- Wrong: Proceed to step 4.

- Step 4: Continuously collect data from the AMG8833 infrared thermal sensor, and check the conditions:

+ If the measured temperature (t) is within the range tmin ≤ t ≤ tmax, display the Normal information along with the corresponding color codes for each thermal zone.

+ If the measured temperature t < tmin, display Low information along with the corresponding color codes for each thermal zone.

+ If the measured temperature t > tmax, display High information along with the corresponding color codes for each thermal zone.

- Step 5: Return to step 3.

3. Experimental Results

We connected the peripheral components, including a power switch, three buttons (Menu, Up, Down), an OLED display, and an IR thermal sensor (AMG8833) to an Arduino Nano, and powered it with a 9V battery according to the circuit diagram shown in Figure 4 and the pin connections listed in Table 1. After assembling and connecting the electronic components, uploading the program to the microcontroller, and enclosing the device, the final product has the appearance shown in Figures 5(a) and 5(b).

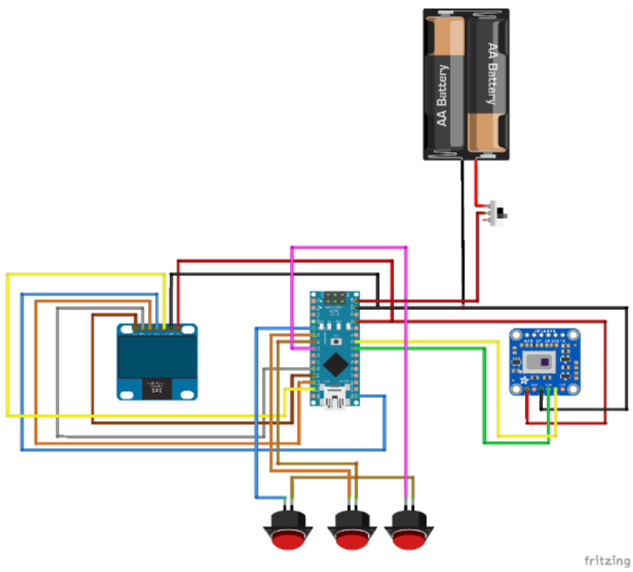


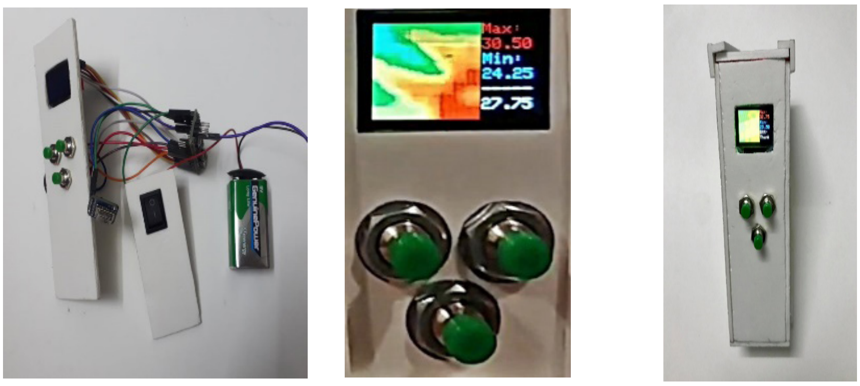
Figure 4. Hardware circuit diagram of the thermal camera's electronic components

Table 1. Pin connections between Arduino, OLED, and AMG8833

Arduino Nano	Oled	AMG8833
GND	GND	GND
VCC	5V	Vin
D13	SCL	
D11	SDA	
D9	RES	
D8	DC	
D10	CS	
A5		SCL
A4		SDA

When the power switch is turned on, the display will show the pixels, color codes, and corresponding temperatures detected within a range of 7 meters by the AMG8833 sensor on the 0.95-inch OLED screen. To set the pixels and adjust their values, the Menu, Up, and Down buttons are used accordingly. Depending on the temperature of the observed area detected by the sensor, the values, alerts, and corresponding color zones are displayed on the OLED screen.

The input information of a handheld thermal camera includes the detected and displayed thermal images on the device's screen. The device can be used to detect and measure the temperature of objects using thermal sensors. The output of a handheld thermal camera is information about the temperature of objects within the scanning range. This result is displayed as a thermal image along with the minimum, maximum, or average temperature of the observed area.



(a) *(b)* *(c)*

Figure 5. (a) Assembled electronic components; (b) information displayed on the OLED screen; (c) final product of the mini handheld thermal camera.

4. Conclusion

Temperature is an important factor in all scientific fields, production, daily life, and human health. Measuring, monitoring, and alerting with temperature values, images, and colors are necessary.

The device developed from the research process can measure and display the color region corresponding to the temperature received in the detection area of the sensor eye. With a compact handheld design, it can set the temperature range (upper and lower thresholds) that needs to be surveyed and the resolution that needs to be displayed on the OLED screen. It is convenient to carry and can be used even in the absence of light. The product can be applied in various fields such as measuring non-contact body temperature, maintaining, repairing, and testing the quality of electronic devices, electrical and mechanical devices, phones, chips, ICs, detecting overheat wires of electrical systems, underground and in-wall cables, electricity and water, detecting gas leaks, ventilation furnaces, heating furnaces, etc.

In addition, this product is also used in the industry to monitor and check the temperature of equipment, machinery, building materials, pipelines, leading to early detection of technical issues and avoiding accidents due to overheating. Moreover, handheld thermal cameras are also used in security and firefighting to immediately detect hotspots in homes and avoid fire or explosion risks.

To expand the scope of application of the research product, improve accuracy, reliability, increase resolution, etc., more measurement sensor eyes can be used, along with wireless communication networks, accurate image recognition and processing algorithms, and large-size display screens for convenient monitoring.

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