Design and Implementation of Raspberry Pi Face Recognition + Thermal Imaging Temperature Measurement and Body Temperature Data Cloud Processing System

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Abstract: For temperature measurement in public places, this paper proposes and realizes a Raspberry Pi face recognition + thermal imaging temperature measurement and temperature data cloud processing system. This system uses a Raspberry Pi device as the temperature measurement terminal, connects the MLX90640 thermal imaging sensor and the BME280 environmental sensor for data collection, and calculates the core temperature of the human body from the collected data. The temperature measurement terminal uses Python language with OpenCV library for image processing, Alibaba Cloud API for face recognition, and the server side uses Python language with Django library for development. The system can quickly measure temperature and count the temperature measurement list, and view it in the cloud in real time to improve management efficiency.

Keywords: Temperature Measurement in Public Places; Raspberry Pi; Thermal Imaging Temperature Measurement; Face Recognition; Data Processing

1. Introduction

1.1 Project Background

During the epidemic period, the General Office of the Ministry of Education and the Comprehensive Department of the National Disease Control Agency issued the "Technical Program for Prevention and Control of the New Crown Pneumonia Epidemic in Higher Education, Elementary and Middle Schools, and Child Care Institutions". The program proposes that "teachers, students and staff need to wear masks, verify their identity and test their body temperature when they enter the school gate," and that "on the basis of the normalized epidemic prevention and control work, schools should strictly implement measures such as health monitoring of teachers, students and staff, temperature testing, morning, afternoon and evening check-ups, and tracking and registering of absences from classes due to illnesses (attendance). ". This has made temperature testing in public places a daily routine during the epidemic. The original way of measuring temperature by forehead temperature gun used in classes is inefficient as it has the disadvantages of inaccurate temperature measurement, taking up teachers' time and requiring manual recording. And the system is designed to solve these problems effectively.

1.2 MLX90640

The MLX90640 is a fully calibrated 32 × 24 pixel high-resolution infrared temperature measurement array chip with a normal operating temperature range of -40 to 300 °C and a temperature measurement range of -40 to 85 °C [1]. Its internal integration of 768 infrared temperature measurement image element, can accurately detect the specific area and temperature range of the target object, support the IIC interface communication[2]. The data collected by each basic image of the probe is converted by the corresponding formula to obtain a temperature value that is the average value of the temperature of the object in its field of view. The MLX90640 needs a certain amount of time to reach thermal equilibrium after startup, and only after thermal equilibrium does it have a relatively stable and high-precision performance. In addition,

infrared sensors are inherently susceptible to errors caused by thermal gradients, so try to avoid subjecting the sensor to heat and transient temperature environments when in use[3].

1.3 BME280

The BME280 temperature and humidity sensor is a small-package, low-power digital composite sensor from Bosch's APSM process [4]. It has high accuracy pressure, humidity and temperature measurement performance with high linearity [5].

1.4 OpenCV

OpenCV is an open-source computer vision library, used in many fields and can be cross-platform, but it is mainly used in the direction of computer vision, OpenCV contains a very large number of functions, can be time-efficient implementation of most of the general algorithms of computer vision[6]. OpenCV contains a lot of functions that can realize most of the general algorithms of computer vision in high time. Among them, OpenCV contains image processing functions that basically include every aspect of image processing, such as: image and video input and output, basic digital image processing, basic image and video display moments, and all kinds of dynamic data structures, and so on[7].

2. System Analysis

2.1 Purpose of Development

The large number of students and wide coverage of schools make it crucial for their epidemic prevention and control measures to be in place. This not only affects the lives and health of millions of teachers and students, but also the overall situation of epidemic control nationwide. Enhancing the targeted, operational, effective, and scientific nature of epidemic prevention and control work is essential, and the temperature measurement system for students and teachers in schools is an important part of this. Parents measure their children's temperature at home before they go to school, temperature checks are conducted at the school entrance, in the teaching buildings, and at the classroom entrances. Schools have established strict multi-level temperature monitoring systems. Classroom temperature checks are conducted at least three times a day, in the morning, at midday, and in the evening, enabling the timely and effective monitoring of students with fever and prompt intervention.

When the system is not applied, the temperature measurement work needs to wait for the classroom to be full of people (such as after the lunch break bell) to send a student one by one to the whole class temperature measurement, the temperature measurement work takes 10 to 15 minutes to complete. The application of this system makes it possible for students to complete the temperature measurement by standing in front of the camera for only 3 to 5 seconds when entering or leaving the classroom. Theoretically, it only takes 150-250 seconds to complete the temperature measurement for the whole class, which is 3-6 times faster and more efficient while removing manual labor.

2.2 Technology Needs

Temperature measurement terminals need to be used in the classroom, the issue of portability must be considered, and there is a certain demand for computing power due to the need for data computation. In the process of use, it is necessary to reduce the temperature measurement time and improve the efficiency of temperature measurement. After use, the data should be viewed at any time to facilitate school statistics.

2.3 System Functions

System development follows the computer software development specification GB8566. The system is analyzed according to the real needs, combined with the existing technology, the preliminary formulation of the system's functions are as follows:

(1) Data acquisition function. When the program is running, it continuously detects the face, and if it is detected, it performs a data acquisition. The data to be acquired are: thermal imaging temperature data, ambient temperature, and camera face pictures;

(2) Data processing queue function. Since it takes some time to send face recognition requests to Alibaba Cloud and data processing, in order to support rapid temperature measurement, it is necessary to add a queue function. When measuring temperature, after data collection, join the queue to leave;

(3) Face recognition function. Due to the need to count the list of temperature measurement,

the terminal for data processing needs to use Alibaba Cloud for face recognition first.

(4) Data processing function. There is a gap between the temperature obtained by the thermal imaging sensor and the body surface temperature, and between the body surface temperature and the core temperature of the human body, and it is necessary to obtain the core temperature of the human body as accurately as possible using the temperature obtained by the sensor.

(5) Cloud data processing function. In order to be able to view data at any time and facilitate statistics for school administrators, the terminal needs to upload the data to the cloud server for preservation after data processing and develop a webpage for easy viewing of records.

(6) Cloud data management function. Convenient for managers to manage data.

3. System Design and Algorithm Implementation

3.1 System Physical Architecture

The system is physically divided into Raspberry Pi and cloud server. The Raspberry Pi is powered using mobile power supply, TF card is used as a storage device, operated using a keypad and mouse, connected with a display, thermal imaging sensor, camera, and environment sensor (Figure 1). Assemble these items to get the finished product (Figure 2).

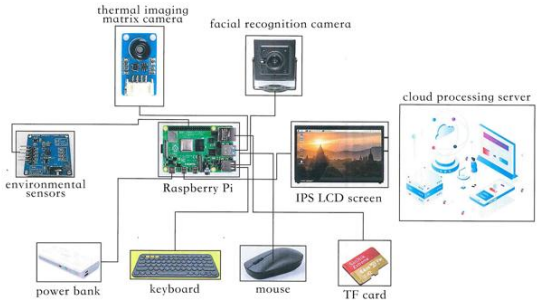

Figure 1. Physical Structure Diagram

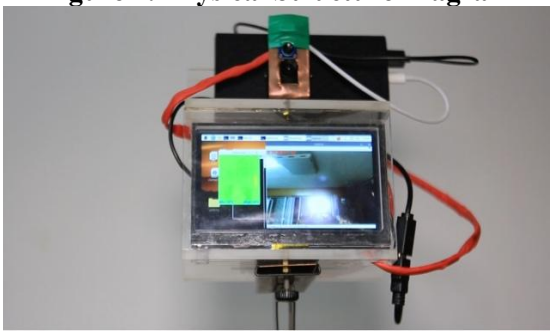

Figure 2. Equipment Physical Diagram

3.2 General Architecture of System Functions

The system is functionally divided into temperature measurement terminal and server side. The temperature measurement terminal faces the temperature measurement users and provides functions such as data acquisition, data processing queue, face recognition, data processing, etc. The server side mainly faces the managers and provides functions such as data storage management, real-time temperature measurement list query, historical temperature measurement list query. The server side mainly faces the management personnel, providing functions such as data saving management, real-time temperature measurement list query, historical temperature measurement list query, and so on.

3.3 Establish the Positional Mapping of Camera Coordinates to the Thermal Imaging Temperature Matrix

Corresponding the face coordinates acquired by the camera to the data of thermal imaging and acquiring the temperature within this range avoids the interference of other hot objects in the frame (Figure 3).

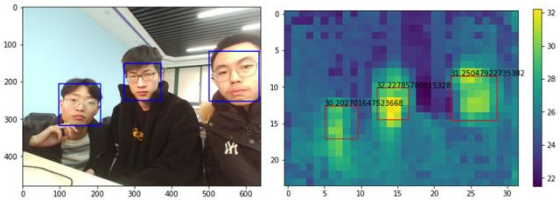

Figure 3. Coordinate Mapping

3.4 Calculation of Human Core Temperature from Sensor Data

According to the relationship between the core temperature of the human body T_c and the human skin temperature T_s, the ambient temperature T_a, after placing the sensor in front of the forehead between 1.5cm ~ 30cm[8]:

$$T_c = (0.001081T_s^2 - 0.2318T_s + 12.454)\cdot(T_s - T_a) + T_s \quad (1)$$

After measuring the body temperature and ambient temperature, the skin surface temperature is calculated, and then the skin surface temperature is subtracted from the maximum temperature in the face range corresponding to the thermal imaging data to obtain the compensation value at this time. T_b Then combine the results of face detection and take:

$$L = \max(width, height) \quad (2)$$

Then, try to fit T_b to L (Figure 4).

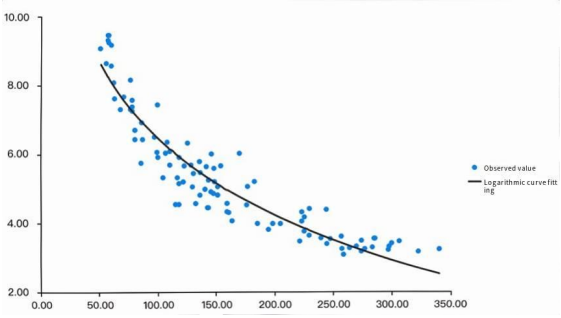

Figure 4. $T_b - L$ Fitted Image

The results of the analysis showed significance (p-value less than 0.05 or 0.01), indicating that the independent variable X has an influential relationship on the dependent variable Y (Table 1).

Table 1. Summary of Regression Coefficients

	non-standardized coefficient		standardized coefficient	t	p
	B	standard error	Beta		
constant	21.207	0.573	-	36.993	0.000**
ln(170)	-3.205	0.115	-0.942	-27.812	0.000**

* p<0.05 ** p<0.01

implicit variable: 4.5880784689117098

4. Functional Design

4.1 Data Acquisition and Data Processing Queues

After running the client program, the acquisition will start automatically (Figure 5), at this time the program will use OpenCV loop to detect the presence of the face. Then, the user needs to approach the camera (Figure 6), follow the prompts to wait a little (Figure 7) to leave, at this time the program will collect thermal imaging data, ambient temperature and camera photos, and added to the face recognition queue. The right queue information area will show the collected data (Figure 8).

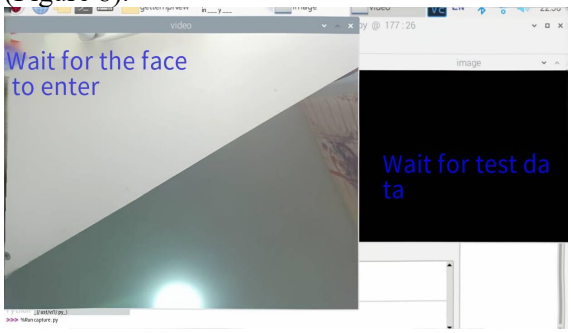

Figure 5. Starting Acquisition

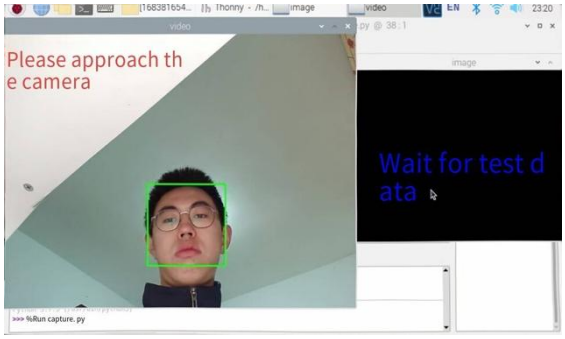

Figure 6. Approaching the Camera

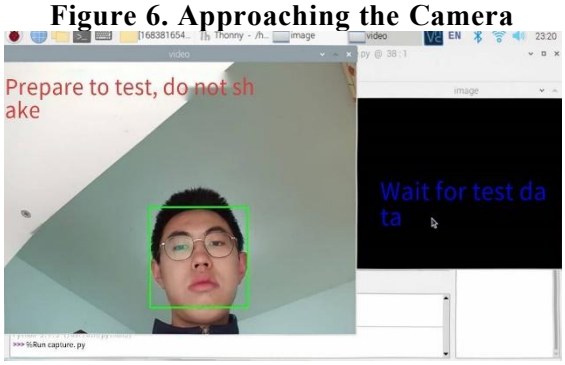

Figure 7. Waiting for Acquisition

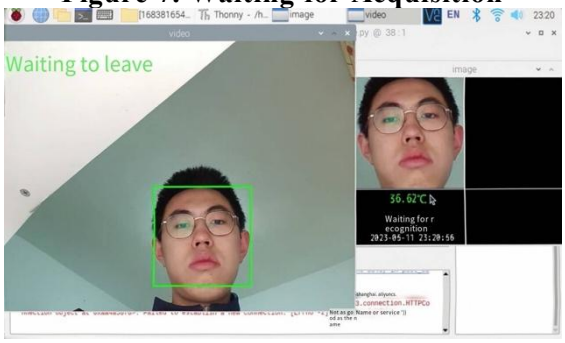

Figure 8. Capture Complete

4.2 Face Recognition and Data Processing

After entering the queue, the program will calculate the core temperature of the human body for display based on the sensor data, and request to Alibaba Cloud face search, and after getting the search results, it will display the temperature measurement results (Figure9) and send the data to the server.

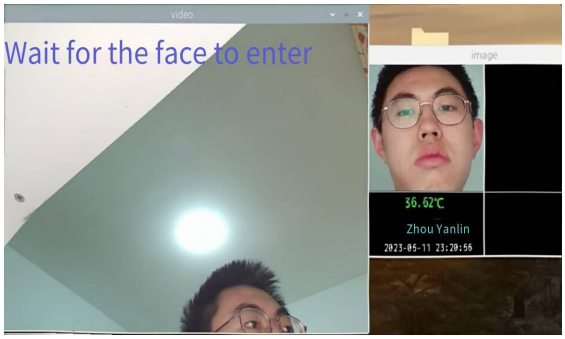

Figure 9. Face Search Completed

4.3 Cloud Data Processing

Once the server receives the data request, it will save the data to the database and make a determination, and if the temperature is abnormal it will be pushed using the pinned bot (Figure 10).

Figure 10. Temperature Abnormality Notification

Go to the main page of the server (Figure 11) and query as required to see a list of all the data for the day or historical tests (Figure 12).

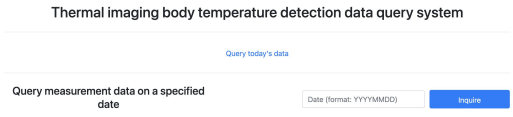

Figure 11. Server Home Page

Figure 12. Data List

4.4 Cloud Data Management

The data within the database can be managed by entering the server backend (Figure 13).

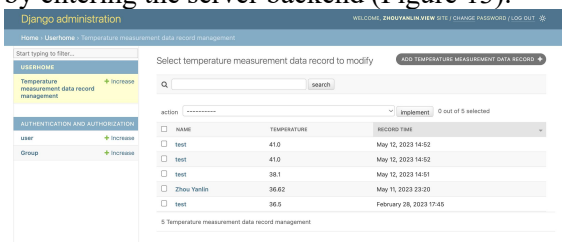

Figure 13. Data List

5. Conclusions

For temperature measurement in public places, this paper proposes and realizes a Raspberry Pi face recognition + thermal imaging temperature measurement and temperature data cloud processing system. The system can quickly measure the temperature and count the temperature list, which can be viewed in the cloud in real time to improve the management efficiency. After testing, the system has good feasibility and stability, and can meet the needs of temperature measurement work in schools, with certain practicality and promotion value.

Acknowledgments

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