# Temperature measurement and identity detection system based on multiple embedded control units and LBP detection algorithm

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**Abstract.** This paper designs a simple non-contact temperature measurement and identity recognition device based on multiple embedded control systems and feature recognition algorithms. The device can achieve multiple functions such as non-contact temperature measurement, face recognition, mask recognition, and smart alarm. The system consists of three parts: main control, interactive system and detection system: the main control selects STM32F407VGT6 to process the data returned by multiple sensors and realize the mutual communication of each system; the interactive system uses the HMI serial touch screen to realize the visualization of data and human Machine operation function; the detection system is equipped with MLX90614 temperature detection module and OpenMV4 machine vision module to realize functions such as temperature detection, face recognition and mask recognition[1]. In addition, in order to ensure the accuracy and stability of the detection results, this article specifically designs temperature data filtering and compensation algorithms, LBP feature detection algorithms and other intelligent algorithms. Through experiments, the accuracy of this device to detect 28℃-48℃ is within 0.8℃, and the accuracy of identifying faces and masks is above 98%.

## 1 Introduction

The overall scheme framework diagram of the system is shown in Figure 1. After the MLX90614 module receives the measurement signal, it starts to measure the temperature and returns the signal. When the temperature reaches or exceeds the threshold, the STM32 main control board turns on the buzzer to alarm through the feedback signal. After OpenMV4 receives the measurement signal, it starts to perform face recognition and other operations on the measurement object, and recognize the measurement object as required. When the object does not match (including the identity does not match and the mask is not worn), the STM32 will be alerted by the feedback signal, and at the same time, the STM32 will turn on the buzzer to alert and the serial screen to alert.

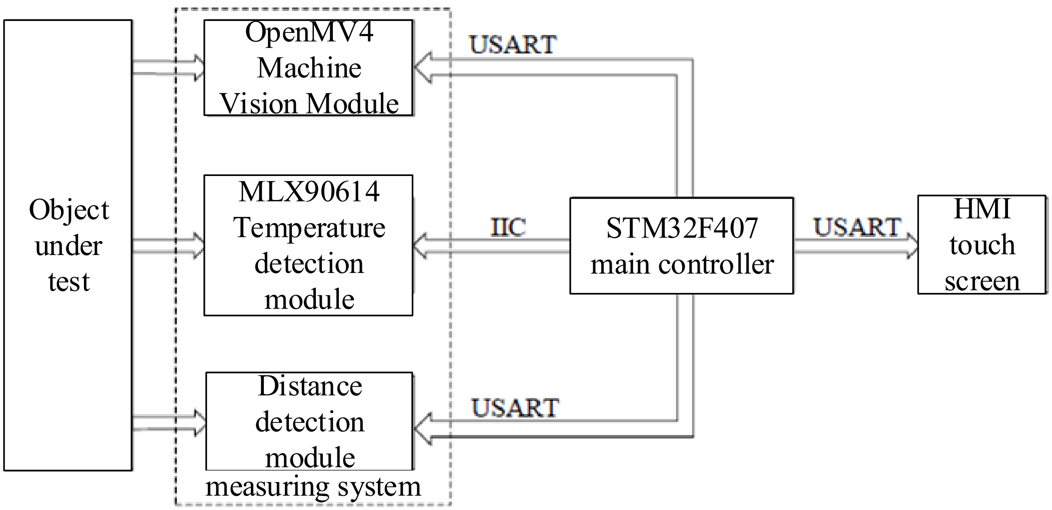


Figure 1.System overall framework diagram

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## 2 Theoretical analysis

### 2.1 LBP face recognition algorithm

LBP[2] is the abbreviation of Local Binary Pattern, which has obvious advantages such as grey invariance and rotation invariance. The original LBP operator is defined as in a 3*3 window, with the central pixel of the window as the threshold, the grey value of the adjacent 8 pixels is compared with it, if the surrounding pixel value is greater than the central pixel value, the pixel The position of is marked as 1, otherwise it is 0. The formal description of the LBP operator can be given as:

$$LBP(x_c, y_c) = \sum_{p=0}^{p-1} 2^{p_s}(i_p - i_c) \quad (1)$$

With $(x_c, y_c)$ as the center pixel, the intensity is $i_c$; and $i_p$ is the intensity of neighbouring pixels. $s$ is a symbolic function, defined as

$$s(x) = \begin{cases} 1 & x \geq 0 \\ 0 & esle \end{cases} \quad (2)$$

The basic LBP operator can cover an area with a fixed radius, and the resulting binary sequence represents the characteristics of the corresponding block. After normalizing the histograms of all blocks in the sample image, the corresponding image characteristics can be obtained vector.

### 2.2 Non-contact temperature measuring element

The MLX90614 temperature measuring element uses a pyroelectric element as the infrared sensing part, and its detection output is the result of the combined effect of the measured object temperature ($T_o$) and the sensor's own temperature ($T_a$). Under ideal circumstances, the output voltage of the pyroelectric element is:

$$Vir = A(T_o^4 - T_a^4) \quad (3)$$

The temperature unit is Kelvin, and A is the sensitivity constant of the element. The target temperature and ambient temperature are measured by the built-in thermocouple.

## 3 System design

### 3.1 Power circuit design

This design uses two chips, TPS54202H and TPS7A7001, to design the auxiliary power supply circuit. TPS54202H chip is a wide input voltage chip, which can accept 12V voltage input, and the chip quiescent current is 45uA. According to its data sheet, in order to make the output 5V when the input is 8-28V, the resistance, capacitance and inductance are selected as $C_1$=10nf, $C_2$=22uf, $C_3$=22uf, $C_4$=10uf, $C_5$=10nf, $C_6$=75pf, $R_3$=49.9Ω, $R_5$ =100k, $R_6$=510k, $R_7$=13.3k, $L_1$=10uH. The TPS7A7001 chip is a high-performance low-dropout regulator with a quiescent operating current of 1uA. According to its data sheet, in order to make the output 3.3V, the following values are selected for the resistance $R_1$=5.1K, $R_2$=510, $R_3$= 1K. The Power circuit schematic diagram is shown in Figure 2.

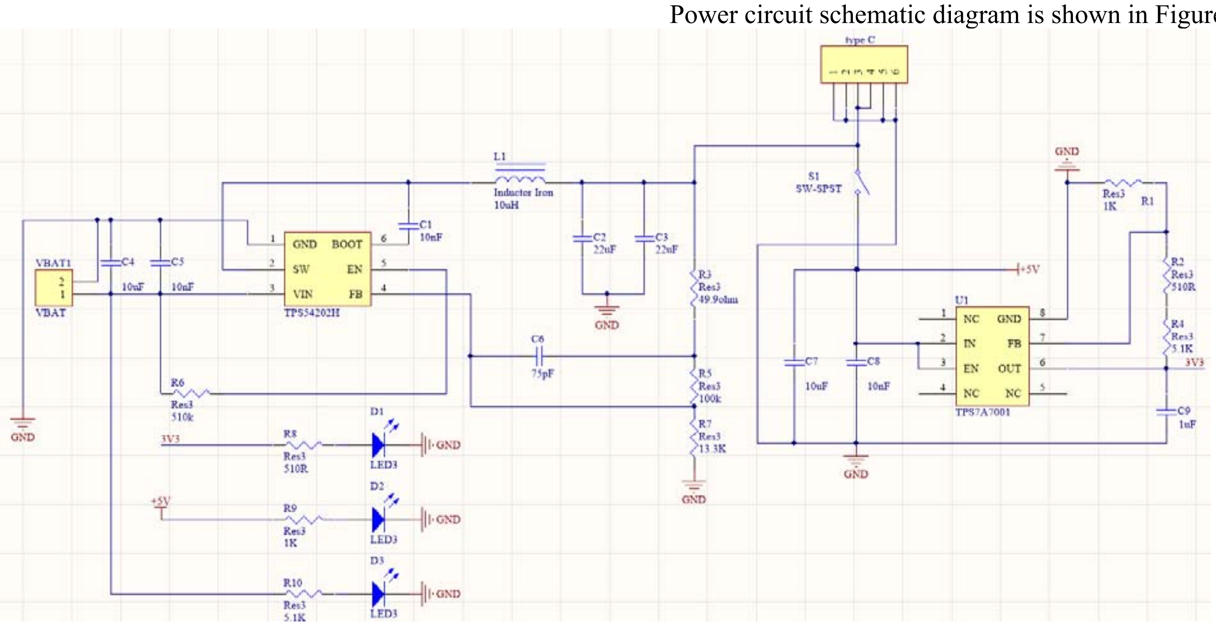


**Figure 2.**Power circuit schematic diagram

## 3.2 Software design

### *3.2.1 Main program design*

In view of the fact that this device is a system composed of multi-sensor modules and mainly realizing software functions, the main program design is composed of three parts: system initialization, data communication and data processing. The system initialization refers to the initialization of functional modules such as the HMI serial screen and MLX90614 to ensure the normal operation of each functional module. The data communication part is for the purpose of data transmission and human-computer interaction. It reads the control demand data from the HMI touch screen through the serial port protocol, and reads the return data from the MLX90614 non-contact temperature measurement module through the SMBus communication protocol. The serial communication protocol receives the corresponding detection result data from OpenMV. After the temperature data and image processing result data are interpreted by data processing methods such as temperature compensation and binarization, the results will be sent to the HMI screen through the serial protocol to send corresponding controls. To achieve the visualization of information.

### *3.2.2 Program design of face recognition and detection*

The simple non-contact temperature measurement and identity recognition device is based on the LBP feature detection algorithm to design a face recognition and detection program, which is mainly divided into three parts: face image acquisition, feature extraction and feature comparison. Before actual recognition and detection, OpenMV will record the faces of the test subjects with different expressions in the form of photos on its SD card as its internal database. When OpenMV starts to recognize, OpenMV will take an image containing the subject's face. This image will be processed by the LBP feature detection algorithm to obtain a series of feature values. This feature value is compared with the face pictures of each tester in the endogenous database. The contrast difference is averaged by the person’s name. If the minimum value of the feature difference is less than the expected value, the tester’s Identity. The face recognition flowchart is shown as in Figure 3.

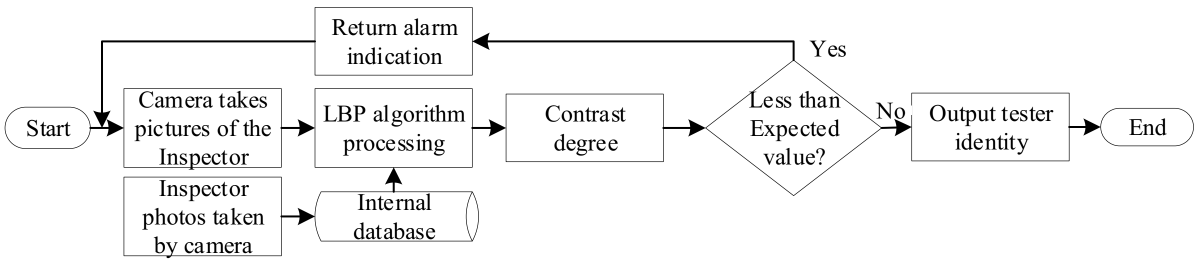


**Figure 3.** Face recognition flowchart

### *3.2.3 Program design for mask recognition and detection*

Simple non-contact temperature measurement and identification device based on Haar-cascade detection algorithm designed mask identification and detection program. The mask detection process uses the mask-cascade feature file that has been trained using the Haar operator in advance. In the actual recognition process, OpenMV will obtain a total of 200 facial images of the subject to be tested. These images will use mask-cascade for feature detection. The pictures whose feature detection value is greater than the threshold is recorded. If the number of recorded pictures among the two hundred pictures is more than the expected value, it can be determined that the subject is wearing a mask normally during this period. The program design flowchart is shown in Figure 4.

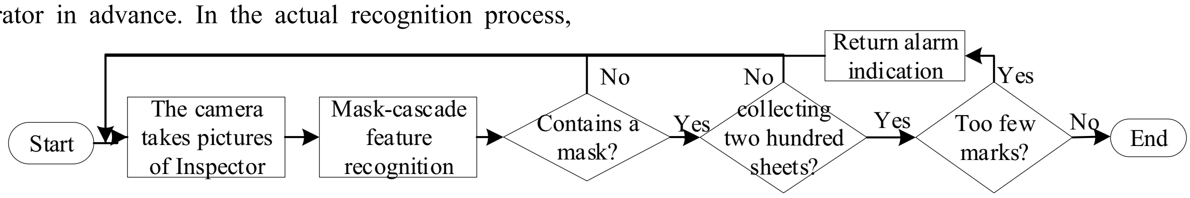


**Figure 4.** mask recognition and detection flowchart

# 4 System test and result analysis

## 4.1 Test program

### *4.1.1 Temperature recognition test*

Place the temperature measuring object on the test bench, use a temperature measuring gun to detect the actual temperature of the object to be measured, and then use a non-contact temperature measuring instrument to measure and record the measurement data.

### *4.1.2 Face recognition test*

Five volunteers were randomly selected from the test site, four of them were entered into the database, and then the order of the five volunteers was disrupted. Volunteers were randomly selected for facial recognition and recorded measurement data.

## 4.2 Test Results

### *4.2.1 Temperature recognition test result*

**Table 1.** Temperature recognition test result table

| Test number | Alarm threshold | Standard temperature | Detect temperature | Whether to alarm | Measurement difference |
|---|---|---|---|---|---|
| 1 | 28 | 30.01 | 30.12 | No | +0.12 |
| 2 | 30 | 35.38 | 35.74 | Yes | +0.36 |
| 3 | 30 | 40.56 | 40.90 | Yes | +0.34 |
| 4 | 45 | 45.32 | 45.45 | Yes | +0.23 |
| 5 | 48 | 47.37 | 47.67 | No | +0.30 |

Conclusion: The temperature measurement system can set the alarm threshold to realize the alarm function and accurately output the object temperature

### *4.2.2 Face recognition test results*

**Table 2.** Face recognition test result table

| Inspector | Detection times | Whether to alarm | Success rate | Average difference |
|---|---|---|---|---|
| Inspector 1 | 50 | No | 96% | 3023 |
| Inspector 2 | 50 | No | 98% | 4079 |
| Inspector 3 | 50 | No | 98% | 3687 |
| Inspector 4 | 50 | No | 96% | 1689 |
| Unlearned | 50 | Yes | 100% | 18653 |

Conclusion: The system has a face recognition success rate of close to 100% for the learned person and can learn the facial features of the person on the spot

## 4.3 CONCLUSIONS

The system can accurately achieve the use indicators, and on this basis, a more accurate mask detection algorithm, a human-friendly interactive interface, and safer mechanical devices have been designed. In the face of the 2020 COVID-19, the device designed in this paper can deal with the detection and identification of fever patients, can serve the society well, and meet the original intention of the design.

# References

1. Lu Shengnan. The design and implementation of the license plate recognition system based on HAAR Cascade[D]. Liaoning University,2018.
2. Genshan Zhang Jianen Tian, Zhe Zhang. Digital image classification algorithm based on LBP and LSSVM[J].LCD and display,2020,35(05):471-476.