A Circuit Design of an Intelligent Face Mask Recognition Detector

Yu Hong, Xiaoyu Li, Yingjie Luo, Lei Ni

Chengdu Technological University, Chengdu 610000, China

Abstract

An intelligent face mask detector based on microcontroller STM32, non-contact infrared sensor MLX90614, and image processing technology is designed to limit the likelihood of epidemic transmission.STM32 single chip microcomputer is used as the control core to obtain the recognition results of openmv face mask through UART, and read the target body temperature data collected by MLX90614 through SMBus protocol. The MLX90614 non-contact body temperature measurement fits the standards for epidemic prevention and control, and the OPENMV vision module efficiently determines whether the mask is worn correctly or not. The experimental results show that the device has a measurement accuracy of ± 0.3 ℃ at about 37 ℃, the recognition rate of face mask is about 0.87, and the real-time display of measurement results is realized. It has a wide application prospect in the field of epidemic prevention and control in the future.

Keywords

MLX90614; OPENMV; Image Processing Technologies; SMBus.

1. Introduction

The COVID-19 is mostly under control in China at this time,but it still faces the possibility of overseas import and the emergence of a small-scale sudden epidemic. How to accomplish regular epidemic prevention and control at this level has become an unavoidable requirement of social and economic growth[1]. As a result of the current crown outbreak, special personnel shall be assigned to supervise and detect the temperature and wearing of masks of people coming in and out of cinemas, schools and other public places.This is a significant task for the detection personnel, as well as a danger of infection.

Shengping Du's team[2] investigated the accuracy of distance measurement in temperature measurement using an FPGA based non-contact temperature measuring system. Based on the work of ShengPing Du's team, GaoXiang Yang's[3] team further studied the accuracy and temperature adjustment of the infrared temperature measurement system. They have studied the accuracy of the non-contact infrared temperature measurement system in depth. However, the prevention and control of the epidemic is not only the accurate measurement of body temperature, but also the correct wearing of masks is an important part in the whole process. Based on existing domestic research, this paper focuses on the identification of mask wearing detection using image processing techniques.

The control core is an STM32F103 microcontroller.The traditional image technology is used to identify the wearing of the mask, and the results are transmitted to the single chip microcomputer for data processing.The MLX90614 infrared temperature sensor collects human temperature without touching it and sends data to the microcontroller using the SMBus protocol, allowing the temperature to be displayed in real time.The solution offers the advantages of ease, effectiveness, and safety. It can effectively lessen the chance of epidemic transmission by reducing the pressure of epidemic prevention as well as the risk of worker infection.

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2. System Design

2.1 Design Structure

Hardware control motherboard; MLX90614 infrared temperature measurement, power supply module, LCD display, OPENMV identification module, and other components make up the primary design of an intelligent face mask recognition detector. The system structure is shown in Figure 1.

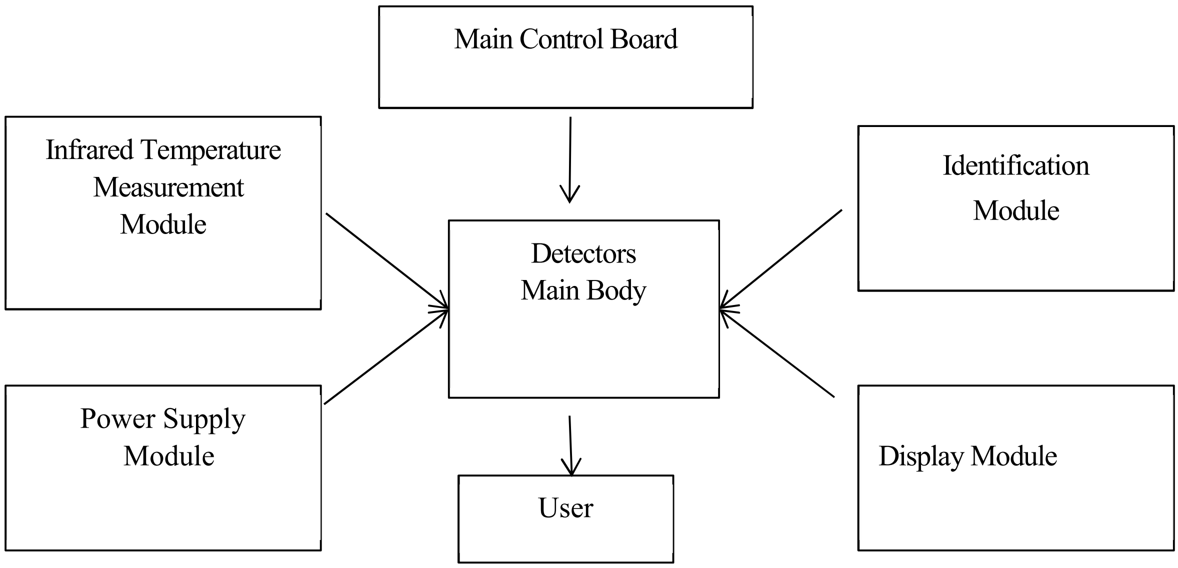

Figure 1. System structure of intelligent face mask detector

2.2 Circuit Structure

The STM32F103 is used as the main control board, and the infrared temperature monitoring module uses the SMBus protocol to transmit and acquire data. OPENMV module communicates with the main control board through UART.A lithium battery with a 5V (voltage) powers the entire circuit.The 5V is divided the voltage into 5V and 3.3V through a voltage regulator circuit to supply the microcontroller, the OPENMV vision module, and the display module.

2.3 Core devices

The main chip is the STM32F1O3, which is based on a Cortex-M3 core with a 72MHz and can efficiently calculate data. All peripheral modules on intelligent face mask recognition detector are controlled by STM32. Interaction of data between modules through different communication protocols for example, the MLX90614 extracts the body temperature of the detector, the display of the LCD screen, and the OPENMV extracts the data of the detector's face mask recognition.

3. Concrete Implementation

3.1 Power Supply Module

The system uses USB-MINI as the interface, as shown in Figure 2. USB1 is an external power input port with a 5V input voltage. D+ and D- are directly coupled to the chip's PA11 and PA12. A triode connects the chip's PD6 pin to the buck output circuit's 3.3V port. To split the 5V voltage into 5V and 3.3V, VCC pin is connected straight to the step-down circuit. To swiftly discharge static electricity interference, prevent a huge quantity of interference energy being generated during the hot plugging process, and to avoid the board being destroyed owing to excessive current,we choose a unidirectional TVS tube (D1) and fuse500mA (F1) to form the interface protection circuit (Figure 3).The 1117-3.3 chip correctly steps down the input 5V to 3.3V, ensuring that the entire circuit has a reliable and consistent power supply.

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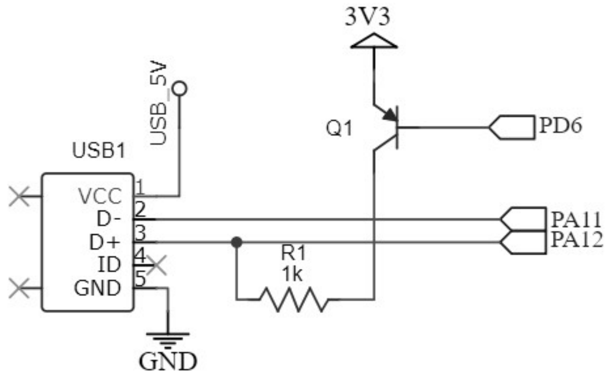

Figure 2. USB input circuit

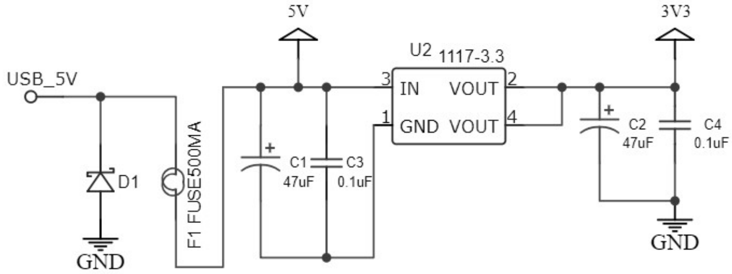

Figure 3. Buck circuit

3.2 Infrared Temperature Measurement Module

The temperature measurement module's fundamental component is MLX90614. The MLX90614 is a non-contact infrared thermometer with the benefits of small size and low costA thermopile detector chip, a dedicated signal processing chip, a low-noise amplifier, and a 17-bit analog-to-digital converter are all included in the TO-39 package[4] .Therefore, the MLX90614's precise body temperature detection boasts a 0.1-degree Celsius precision.The precision achieves 0.1℃ in a working environment temperature of -40℃ to 125℃, and the temperature of the measured object is around 37 °C, which can fully fulfill the demand.PWM output and SMBus compliant protocol allow the MLX90614 to read temperature values. To read temperature information, this system uses the SMBus communication protocol. Figure 4 depicts the sensor hardware circuit.The MLX90614 communicates with the STM32 main control chip through SMBus, with the SDA and SCL pins connected to PB9 and PB8 of the chip via 4.7K pull-up resistors.

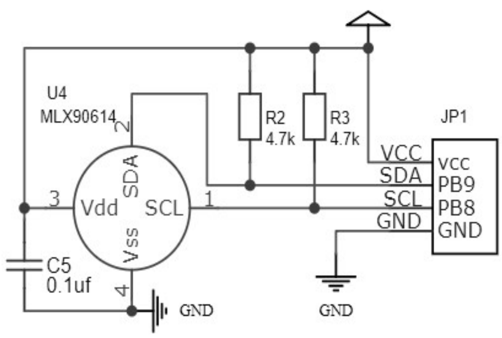

Figure 4. Infrared temperature measurement circuit

3.3 Identification

The STM32H743 Cortex M7 CPU is at the heart of OPENMV, which also includes an Ov7725 sensor, USB interface, SD card slot, analog-to-digital converter, and digital-to-analog converter.The

OPENMV4 H7 camera collects face-mask data, which is used to train the neural network model. Openmv4 H7 is used for face mask recognition. The recognition result is passed through UART_ TX, then sent to the main control chip and drives the corresponding peripherals to work. The pin connections are shown in Table 1.

Table 1. Pin connection method

	OPENMV	STM32F103
Connection method	UART_RX	PA2
	UART_TX	PA3
	3V3	3V3

3.4 Display Module

The core of the LCD is the ILI9341 chip. The internal structure is shown in Figure 5. The GRAM, which is at the center of the structural diagram, is the most important component.GRAM's memory cells correlate to LCD pixels, while other modules work together to turn the data into LCD panel control signals, causing a given pixel to show in a specific color.

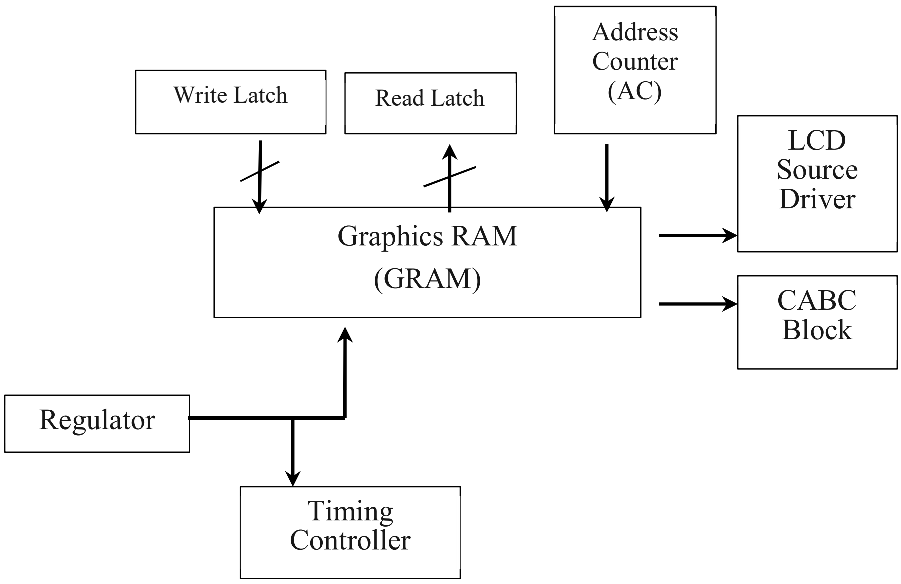

Figure 5. ILI9341 structure diagram

The 8080 communication interface is used by the ILI9341 chip, and the STM32 communicates with it over this interface.Commands and memory data are the key components of the connection. The ILI9341's control instructions are called commands, and the RGB value of each pixel is called memory data.The STM32 transmits commands to the ILI93141 over the 8080 interface to manage its operation, such as setting cursor commands, reset commands, and so on.The LIL9341's 8080 interface timing can be used to simulate software communication across the STM32's common IO port pins, but this system relies on the official STM32 peripheral FSMC to do so because it is efficient.

The ILI9341 LCD can be controlled by the STM32 via the FSMC. Here's how it works: Through the FSMC external to 8080 interface, the STM32 creates communication timing, writes data to the ILI9341's memory, and controls the LCD display.Figure 6 shows the IO pin connections.NOR Flash type mode B is used to control the LCD.Table 2 shows the results.

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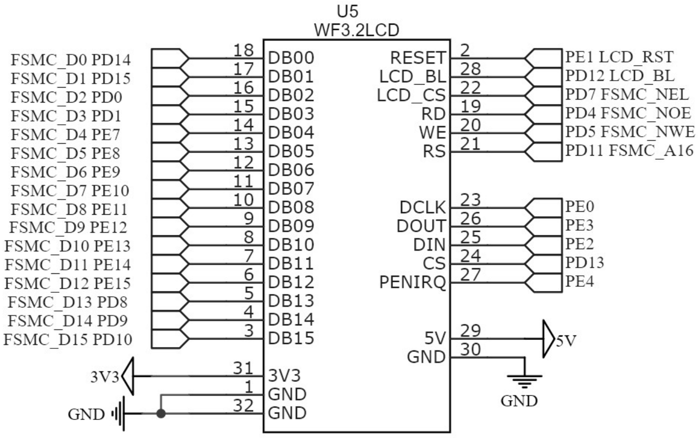

Figure 6. LCD circuit

Table 2. Signal lines

FSMC signal name	Signal Direction	Function
CLK	Output	Clock (used in synchronous burst mode)
A[25:0]	Output	Address Bus
D[15:0]	Input/output	Bidirectional Data Bus
NE[x]	Output	Slice selection, x=1.. .4
NOE	Output	Output Enable
NWE	Output	Write Enable
NWAIT	Input	NOR flash requires FSMC wait signal
NADV	Output	Address, latching signal when data lines are multiplexed

4. Experimental Testing

The reference temperatures for the experimental body temperature measurement were a mercury thermometer for axillary temperature (hereafter referred to as axillary temperature) and an infrared ear thermometer for ear temperature (hence referred to as ear temperature). The axillary temperature of 36.93 degrees Celsius and the ear temperature of 36.95 degrees Celsius were adopted as the reference temperature of the human body, using data from numerous body temperature methods in the literature[5].The measurement time is not easily too lengthy, the measurement interval is 5s[6], and the measurement is performed at room temperature of 20 degrees Celsius to reduce human error in the experiment.Table 3 shows the results of the MLX90614 test. The table demonstrates that at 37 degrees Celsius, the absolute inaccuracy of the MLX90614 is within 0.3 degrees Celsius, and the accuracy fulfills the requirements of the general situation for body temperature.

Table 3. MLX90614 temperature table

Angle (°)	Temperature (℃)	Absolute error of axillary temperature (℃)	Absolute error of ear temperature (℃)
0	37.06	0.13	0.11
45	37.09	0.16	0.14
90	36.81	0.12	0.14
135	37.11	0.18	0.16
180	36.74	0.19	0.21

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```
E: 1.00,  to: 35.64,  ta: 23.45, bo 37.28
E: 1.00,  to: 35.86,  ta: 23.47, bo 37.45
E: 1.00,  to: 35.70,  ta: 23.47, bo 37.36
E: 1.00,  to: 35.70,  ta: 23.51, bo 37.36
E: 1.00,  to: 35.75,  ta: 23.57, bo 37.36
E: 1.00,  to: 35.82,  ta: 23.58, bo 37.45
E: 1.00,  to: 35.92,  ta: 23.63, bo 37.54
E: 1.00,  to: 35.76,  ta: 23.64, bo 37.36
E: 1.00,  to: 35.76,  ta: 23.67, bo 37.36
E: 1.00,  to: 35.73,  ta: 23.69, bo 37.36
E: 1.00,  to: 35.69,  ta: 23.70, bo 37.28
E: 1.00,  to: 35.64,  ta: 23.75, bo 37.28
E: 1.00,  to: 35.48,  ta: 23.79, bo 37.11
E: 1.00,  to: 35.45,  ta: 23.80, bo 37.11
E: 1.00,  to: 35.41,  ta: 23.86, bo 37.11
E: 1.00,  to: 35.41,  ta: 23.89, bo 37.11
E: 1.00,  to: 35.53,  ta: 23.91, bo 37.19
E: 1.00,  to: 35.54,  ta: 23.95, bo 37.19
E: 1.00,  to: 35.73,  ta: 23.97, bo 37.36
E: 1.00,  to: 35.69,  ta: 24.01, bo 37.28
E: 1.00,  to: 35.35,  ta: 24.03, bo 37.03
E: 1.00,  to: 35.48,  ta: 24.04, bo 37.11
E: 1.00,  to: 35.47,  ta: 24.08, bo 37.11
E: 1.00,  to: 35.48,  ta: 24.13, bo 37.11
E: 1.00,  to: 35.38,  ta: 24.13, bo 37.03
E: 1.00,  to: 35.48,  ta: 24.20, bo 37.11
E: 1.00,  to: 35.35,  ta: 24.20, bo 37.03
```

Figure 7. MLX90614 actual measurement data

The photos in this project datasets were picked from images with simple backgrounds and evident mask features to limit the influence of background features on the extraction of mask features during training and to increase the robustness and accuracy of the training model.We used a background complex environment to test the accuracy of the model while assessing the actual effect of the model in order to make the trained model more practical, and the actual measurement results are given in Table 4.

Table 4. Recognition rate of masks

	Test Library Name	Recognition rate
Wearing mask	Wearing only a mask	0.928
	Wearing a mask plus glasses	0.872
	Wearing a mask with sunglasses	0.815
Not wearing mask	Not wearing a mask	0.915
	Wearing glasses without a mask	0.892
	Wearing sunglasses without a mask	0.798
	Not wearing a mask with a similar object to cover the mouth and nose	0.216

```
4.662268 fps
**********
Predictions at [x=0,y=0,w=240,h=240]
face = 0.066667
mask = 0.937255
4.662241 fps
**********
Predictions at [x=0,y=0,w=240,h=240]
face = 0.054902
mask = 0.949020
4.662267 fps
**********
Predictions at [x=0,y=0,w=240,h=240]
face = 0.105882
mask = 0.898039
4.662241 fps
**********
Predictions at [x=0,y=0,w=240,h=240]
face = 0.152941
mask = 0.850980
4.662266 fps
```

Figure 8. Mask identification measurement data

5. Conclusion

Based on the temperature measurement module MLX90614, an intelligent face mask detector used in cinemas, shopping malls and other public places is designed by using image processing technology. The results suggest that the detector's hardware design is robust and dependable, and that the temperature detection error is within the acceptable error range for daily body temperature measurement.Even in complex situations, image recognition technology can detect whether a face is wearing a mask. It has ramifications for China's present epidemic's successful prevention and containment.

Acknowledgments

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