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Automatic Non-Contact Temperature Detection for Health Monitoring

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Abstract: **COVID-19 has made a significant impact on temperature measurement of the human body for primary diagnosis of COVID. Non-contact temperature detection using MLX90614 sensor has been widely used in practice to avoid spread of diseases due to the contact. The thermal gun used to measure temperature is required to be operated by operating personnel. In this paper an automated non-contact temperature detection system is developed and tested. The paper also includes sending the temperature data with a timestamp. The kit developed for the measurement of temperature includes height adjustment mechanism and buzzer alert to indicate higher temperature and make surrounding people know about it. The project proposed in the paper has been developed as a kit with a stand and wheels for easy porting. The project is funded by NexGen IEDC.**

Index Terms: **MLX90614 sensor, non-contact temperature detection, Ultrasound sensor.**

I. Introduction

With the outbreak of COVID across the world, it became the primary diagnosis of temperature in public places like educational institutes, shopping malls and including workplaces. The general mechanism of measuring the temperature is, by using a thermal gun for which operating is mandatory which puts the operating person at high risk of spread of the disease. To avoid manual intervention in measuring the temperature, an automated non-contact temperature detection kit is prepared with a high reliability and precision measurement. The device is designed with better user experience and calibrated with consideration of real time temperature measurement.

A. Temperature measurements

The human body temperature measurement is done by placing the thermometer probe under the tongue in the mouth and holding it for three minutes till the beep from the device. Rectal thermometers are used for infant babies to measure the temperature as it is difficult to make the babies hold the thermometer for a longer time. Color changing plastic strips are available to measure the temperature and it is not highly accurate [1].

Temperature measurement became the greatest concern for primary diagnosis.

II. Proposed System

Due to the advent of various non-contact temperature detection products are available in the market with decent accuracy but it requires manual intervention. The product proposed, designed and developed does not need human presence to measure the temperature.

A. Literature Survey

Giovanni Battista Dell Ísola, Elena Cosentini , Laura Canale , Giorgio Ficco and Marco Dell' Isola, MDPI, 2021, To address this issue, researchers have developed an uncertainty evaluation and screening decision rule to guide the use of non-contact temperature measurement devices. This rule considers the uncertainty associated with the measurement, as well as the prevalence of COVID-19 in the population being screened [2]. It recommends a screening decision based on a combination of the measured temperature and the estimated uncertainty of the measurement.

In addition to this decision rule, it is important to use non-contact temperature measurement devices in conjunction with other measures, such as symptom screening and social distancing, to prevent the spread of COVID-19. These devices should also be regularly calibrated and maintained to ensure accurate and reliable measurements.

Overall, non-contact body temperature measurement can be a useful tool in preventing the spread of COVID-19, but it should be used in conjunction with other measures and with an understanding of its limitations and uncertainties. The uncertainty evaluation and screening decision rule can help guide the use of these devices in a way that maximizes their effectiveness while minimizing the risk of false positives or false negatives [3].

G Teran, J Torrez-Llanos, T E Teran-Miranda, C Balderrama, N S Shah, P Villarroel, Child Care Health Dev. 2012 Jul, 'Clinical accuracy of a non-contact infrared skin thermometer in pediatric practice, to address this issue, researchers have developed an uncertainty evaluation and screening decision rule to guide the use of non-contact temperature measurement devices. This rule considers the uncertainty associated with the measurement, as well as the prevalence of COVID-19 in the population being screened.

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A. Proposed System

The MLX90614 human body temperature sensor can measure temperature using infrared technology by detecting the obstacle at which temperature is to be measured. The temperature sensor uses the output of an HCSR04 ultrasonic sensor that detects the object or person whose temperature is to be found. The LCD screen, which is a flat-panel display [6], uses the light-modulating properties of liquid crystals combined with polarizers in order to display characters effectively on the screen to display messages such as “Please Proceed”, “Calculating temperature, do not remove your hand”, etc.

The Raspberry Pi 4 can be used to measure temperature using the MLX90614 infrared thermometer sensor. This sensor is a non-contact temperature measurement device that uses infrared radiation to measure the temperature of an object or surface without physically touching it [7].

To use the MLX90614 sensor with the Raspberry Pi 4, you will need to connect it to the GPIO pins on the board. The MLX90614 communicates using the I2C protocol, which is supported by the Raspberry Pi. You will need to enable I2C communication in the Raspberry Pi configuration settings and install the necessary Python libraries for interfacing with the sensor.

Once the sensor is connected and the software is set up, you can use Python code to read the temperature measurements from the MLX90614 sensor. The sensor can measure temperatures ranging from -70°C to +380°C with an accuracy of ±0.5°C.

You can also use machine learning techniques to analyze the temperature data collected by the sensor. For example, you can train a machine learning model to detect anomalies in the temperature readings, which could indicate a malfunctioning system or a potential safety hazard.

Overall, the Raspberry Pi 4 and the MLX90614 sensor can be used together to measure temperature and apply machine learning techniques for advanced analysis. This can be useful in a wide range of applications, such as industrial monitoring, environmental sensing, and medical research.

in order to ensure that the concentric hollow rods stay in place at various height levels [8].

Power the Sensor using a regulated +5V through the VCC and Ground pins of the sensor. The current consumed by the sensor is less than 15mA and hence can be directly powered by the on board 5V pins (If available). The Trigger and the Echo pins are both I/O pins and hence they can be connected to I/O pins of the microcontroller.

To initiate the measurement process of the ultrasonic distance sensor, the trigger pin must be set to a high state for a duration of 10 microseconds before being turned off. This action will generate an ultrasonic wave with a frequency of 40Hz from the transmitter.

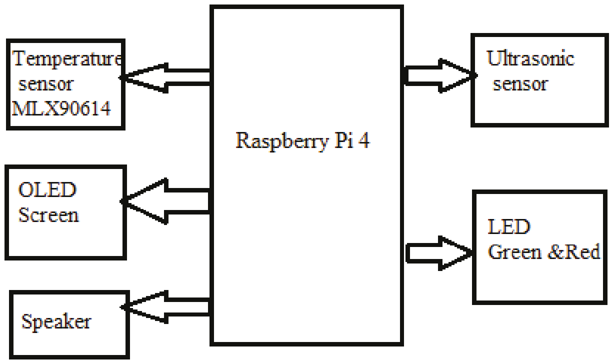

Figure 1. Block diagram of proposed system

The receiver will then wait for the wave to bounce off an object and return to the sensor. When the wave returns, it causes the Echo pin to go high for a specific duration, which is equivalent to the time taken for the wave to return to the sensor after reflection. The microcontroller unit or micro processing unit measures the duration during which the Echo pin remains high, providing information on the time taken for the wave to return [5]-[8]. This information is then used to calculate the distance, as discussed in the preceding section.

Figure 1 presents the block diagram of the proposed system's architecture, illustrating the controller, the temperature sensor MLX90614, and the ultrasound sensor acting as a distance sensor to detect obstacles in the path of the infrared radiation. Figure 2 demonstrates the circuit connections between the different components in the proposed system. Finally, Figure 3 displays the product schematic of the proposed automated non-contact system.

Obstacle sensor recognizes the obstacle or person’s entry detects the temperature if the person puts his/her hand near to the MLX90614 sensor and records the temperature. If the temperature is greater than a preset value then it objects the person’s entry into the place giving an alarm by raising a red colored indication otherwise, it will allow the person into the premises and is shown in flowchart in Figure. 4.

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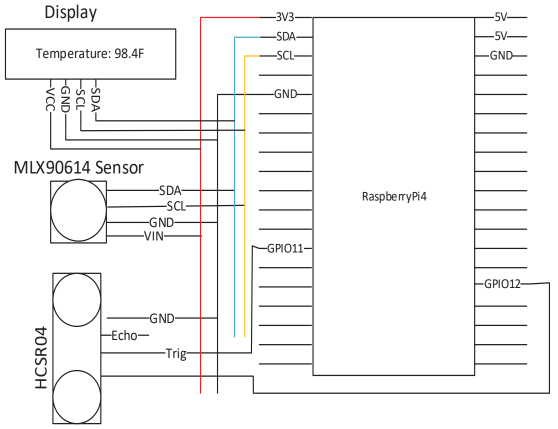

Figure 2. Circuit connection of proposed system

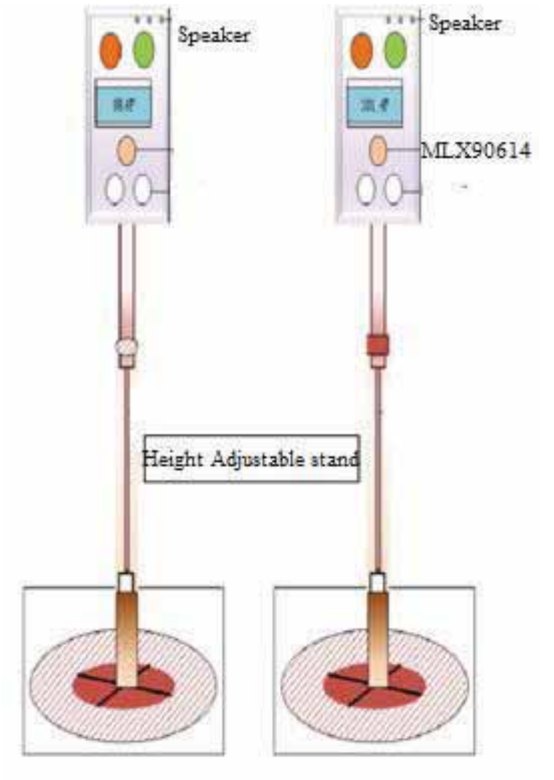

Figure 3. Product structure

Figure3. shows the structure and with a height adjustable mechanism so that a customized height with reference to children and adults height.

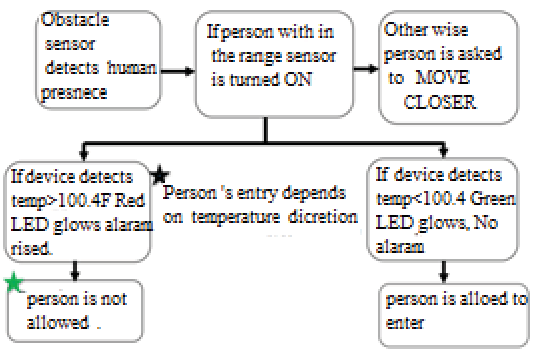

Figure 4. Flowchart of operation of proposed system

TABLE I.
MODULES /SENSORS USED IN THE PRODUCT

S.no	Sensor/Module	Model	Operating Voltgae	Operating range
1.	Infrared Temperature Sensor	MLX90614 ESF-DCI	3V to 5V	-45°c to 85°c 1 - 20cm
2.	Raspberry Pi 4 Model B	Broadcom BCM2711, Quad core	5V	5V/2.5A DC power input
3.	LCD Display	HD44780	5V	20x4 size
4.	Obstacle Sensor	HC SR04	5V	2cm to 80cm
5.	Speaker	SR-887	5V	AUX Line-In speaker

TABLEI. indicates the modules and sensors used in the automated non-contact temperature detection system.

The MLX90614 is a non-contact infrared thermometer that measures temperature. It contains both an IR-sensitive thermopile detector chip and a signal conditioning ASIC integrated into the same TO-39 can. The MLX90614 features a low noise amplifier, a 17-bit ADC, and a powerful DSP unit, enabling it to achieve high accuracy and resolution in temperature measurement [9].

The HCSR04 is an ultrasound sensor that can be used to measure distances non-invasively. It operates by sending out ultrasonic waves from the transmitter and detecting the waves that bounce back to the receiver. The time taken for the wave to travel to the object and back to the receiver is used to calculate the distance between the sensor and the object [10].

The HCSR04 has four pins: VCC, Trig, Echo, and GND. The VCC pin is connected to a power supply, typically 5V. The Trig pin is used to initiate the measurement process by sending out a high pulse of at least 10 microseconds [6]. The Echo pin is used to measure the time duration for which the pin remains high, which corresponds to the time taken for the wave to return. The GND pin is connected to ground.

A 16x4 LCD character display is a type of alphanumeric display module that can show up to 16 characters per row and 4 rows of characters. These displays are commonly used in various applications such as medical instruments, industrial equipment, and consumer electronics [11].

The LCD display module typically consists of a controller chip, a display driver, and a backlight. It can be interfaced with a microcontroller or other electronic circuits through various communication interfaces such as parallel or serial. The display can be customized to show different fonts, sizes, and styles of characters [6].

III. MECHANICAL DESIGN

A. Casing for Components

The electronic components of the device are enclosed in a 21.5x22x22 cubic cm metal box. Device view and dimensions are cited in Figure.7.

As shown in the image, the place at which a person is required to show their hand is very clearly indicated through yellow colored protrusion. Highlighting this area ensures that a person has no confusion whatsoever, regarding where they should place their hand. Within the highlighted cylindrical protrusion, obstacle sensor and IR temperature sensor are present.

The inside of the metal enclosure is outfitted with insulating fiberglass, which ensures that no short circuit condition is possible.

The PCB is held in place within the casing through screws, and a separate slot is created for the power source inside the enclosure. Panel dimensions are shown in figure. Two slots, one for power line-in/charging and other for battery percentage indicator are present. System is operated (ON/OFF) through a switch fitted in the back panel, through a push button. The casing is painted with rust resistant, triple coat blue paint for aesthetics and surface corrosion protection.

Figure.7. Mechanical Design

IV. Methodology

The automated non-contact temperature detection using MLX90614 sensor is mentioned in the following steps.

1. When a person stands at the designated area in front of the device, and shows his palm as instructed on the device screen, the obstacle sensor detects the presence of a person.
2. The obstacle sensor triggers the high accuracy IR temperature sensor to take a reading of the person's body temperature.
3. The temperature sensor takes multiple readings, and the device averages out the readings to arrive at the exact and accurate temperature of the person.
4. If the person's body temperature is detected to be above a pre-set temperature (100.4 F in this case), this means that the person has a fever.
5. In this case, the device immediately displays a message asking the person to stop, and a red bulb glow, signifying abnormal temperature.
6. At the same time, a siren is heard along with a voice message, to indicate to the people around that a potential threat to health has been detected.
7. However, if a person's temperature is detected to be within normal limits, then a message flashes on the screen, advising him/her to proceed.
8. Along with the message, a green bulb lights up, and a voice is heard asking the person to proceed.
9. Thus, our device is user friendly, as the user is directed through both messages on the screen, as well as through green and red-light bulbs in a visual and auditory manner.
10. This ensures that even illiterate people can use the device with no difficulty.

The temperature is measured using a commercial thermal gun and is compared with an automated non-contact temperature device that is designed and developed at the NewGen center at CVR College of Engineering. Table II. compares the temperature measurement using both methods. The temperature sensor of this device has been calibrated by keeping a medical grade, high accuracy Intext non-contact-based thermometer as reference.

Subject's body temperature was measured using our device first, and the standard thermometer next. The results are tabulated as cited in TABLE II. There is close to zero variation between the temperature reading taken by our device, and the medical grade thermometer. In a similar manner, the obstacle sensor was also tested, and its readings (in terms of distance of an object from the sensor) were found to be accurate,

The sensor calibration process was carried out, to ensure highly accurate readings at every instance.

TABLE II.
Temperature Comparison

S. No.	MLX90614 Sensor (Observed) Temperature measured(F)	High accuracy Contact Thermometer based Thermometer (Expected)(F)	Error value (F) (Observed-Expected)
1.	96.8	96.7	0.1
2.	97.3	97.2	0.1
3.	96.4	97.0	-0.6
4	98.6	98.9	-0.3
5.	97.7	97.7	0
6.	96.9	96.6	-0.3

Figure 7. Temperature measurement comparison

V. Conclusions

The need for a Non-Contact Temperature Detection System in the present society where COVID-19 has become a part of our life. The technology, working, circuit diagram as well as the design of the device have been illustrated in detail. The calibration of the temperature sensor, compared with standard temperature sensor has been done, and it has been found to be highly accurate. The mechanical design and integrity of the device casing has been discussed to be resilient. Thus, this device can provide a one stop Non-Contact Temperature solution to be used in all public places. Adding the features mentioned in the future scope section of this document will extend the usability of the device even further. Owing to the accuracy, easy-to-use, as well as the time pertinent nature of our device, our project can be a useful tool in the arsenal in the fight against COVID-19. Face mask detection can be incorporated by implementing Machine Learning algorithms.

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