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Design and Construction of A Non-Contact Thermometer with Environmental Calibration for Health Monitoring

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ABSTRACT: Fever is a common symptom of many infections, keeping monitoring devices like thermometers in constant demand. Temperature is an important vital sign for assessing acutely unwell individuals, and is measured frequently in primary care. However, non-contact measurement of temperature can be very challenging as majority of the temperature measuring devices require physical contact. As most diseases spread through human contacts and touching of surfaces, it is therefore very necessary to come up with ways that general hygiene can be more enhanced. It was upon this conviction that we have proposed this system, "Design and Construction of a Non-Contact Thermometer with Environmental Calibration for Health Monitoring". This we achieved by interfacing MLX90614 Non-Contact Temperature Sensor Module with Arduino Nano Development Board as a microcontroller. The reading of this thermometer was made to display on a 1602 LCD Module that serves as our screen. The coding was done in Arduino IDE using C++ programming language. The systems is powered by a 5 V rechargeable DC source and have reliability of over 98% when compared with the standard thermometer found in the hospital.

KEYWORDS: Diagnosis, microcontroller, fever, thermometer, sensor, calibration, coding, transmission, construction.

I. INTRODUCTION

In recent years, the world has experienced multiple outbreaks of highly infectious diseases, including Ebola, SARS, and most notably, the COVID-19 pandemic. These diseases spread rapidly, often through close contact with infected individuals. One common symptom shared by these diseases is fever, making body temperature a crucial indicator for identifying potentially infected individuals. Traditional thermometers, which require direct contact with the skin, pose a risk of cross-contamination and further spread of infections in crowded environments like hospitals, airports, and public spaces. Therefore, there is a growing need for non-contact thermometers that can detect fevers from a safe distance, reducing the risk of transmission.

Non-contact thermometers are infrared-based devices capable of measuring body temperature without physical contact. They work by detecting the infrared radiation emitted by the human body and converting it into a temperature reading. In addition to the need for fast, reliable, and accurate temperature measurements, another important consideration is the ease of use and portability of the device. Various studies and projects have been conducted to improve the design and efficiency of non-contact thermometers. These include enhancements in sensor technology, more efficient data processing, and integration with wireless communication platforms for remote monitoring and data sharing. Advances in infrared sensor technology, for example, have led to improved accuracy and faster response times, making them ideal for mass temperature screenings (Tao et al., 2021).

In this study, the focus is on the design and implementation of a non-contact thermometer aimed specifically at the detection of fever across various ages. The device is expected to provide real-time temperature measurements of the human body and that of its immediate working environment with high precision, enabling rapid identification of individuals who may require further medical evaluation. The non-invasive and non-contact nature of the device is essential for reducing the risk of infection transmission, especially in high-traffic areas where large numbers of people are screened daily.

These devices offer several advantages, including fast and safe screening, monitoring, and portability. However, challenges such as environmental interference, accuracy issues, and privacy concerns were addressed in the course of this work.

II. METHODOLOGY AND MATERIALS

The non-contact thermometer for health monitoring which involves the integration of hardware (sensors) and software (data processing algorithms) to provide continuous health monitoring and diagnosis. The materials used for the project are separated into two parts: hardware and software. This system hardware contains the following material/ components: mlx90614 non-contact temperature sensor module, arduino nano development board**,** 1602 lcd screen, 5 v dc source, male and female header pins, connecting wires, patrax box, drilling tools, soldering iron and soft solder, hot gun, candle gum, vero-board and breadboard.

The software implementation of the project uses the source code attached at the Appendix of this work. The coding was done in Arduino IDE (Integrated Development Environment) using C++ Programming Language, after which it was tested, debugged, and then uploaded into the Arduino Nano Development Board. The Arduino Integrated Development Environment - or Arduino Software (IDE) - includes a text editor for developing code, also a message area, a text console, a toolbar with buttons for common functions, and a series of menus. This Arduino IDE is supported by Windows 10. The entire system was simulated using both Proteus and Multism simulation software.

The methodology provides a comprehensive. Here, we have used bottom-top software development approach, which is, designing each module individually and then carry out unit testing, before finally integrating them as a whole. The advantage of using this software development approach is that each module can be reused. Also we have used MLX90614 Non-Contact Temperature Sensor Module interfaced with an Arduino Nano as a Microcontroller to monitor and read the human temperature and display it on a 1602 LCD screen that serves as our display unit here. Our ultimate aim is to provide hygienic and efficient means of taking body temperature. The system is a smart device that can take the temperature of any individual or object by merely coming close to it without actually making contact with it. The system displays its reading in digital form in degree Celsius, making it very easy for anyone to read without any special training. We have designed this system in the nature of a smart device that can not only be used by athletes, but by anyone to monitor and read his temperature without any contact during a workout. The Arduino Nano serves a Microcontroller that controls and coordinates the actions of all the components used in the system .

The whole system was contained inside a Patrax container to protect it from moisture, dust, and to make it more presentable. An analog switch was installed to turn ON and OFF the system to save the battery life. The system is powered by a 5 V rechargeable DC source. There are two main methods used to systematically examine and interpret the data that is gathered:

1. The primary source
2. The secondary source

- **Primary source of data**

This mostly focuses on having express contact with staff members or subject-matter experts in the discipline the researcher is studying. Direct observation and interviews are the main methods used to gather primary data for this study.

Interview: Here, we have used interview-oral awarding of questions to employee of Park Lane Hospital, Enugu and Fine Brothers Electronics, Enugu. This method of data collection yields high accuracy because there is no room for assumptions; all information gotten are facts. The information is trusted to be authentic as Park Lane Hospital, Enugu and Fine Brothers Electronics, Enugu are names to be trusted as far as Health and Electronics business are concerned in Nigeria. The presentation of oral questions to respondents was to assist the researcher find a leverage ground of the technical know-how on the impact of implementation of Non-Contact Thermometer in our health institutions.

Direct observation: The interview was complemented with personal observation on the routine of various health institutions and electronic workshops.

- **Secondary source of data**

In the course of this research, data were also gathered from some secondary sources such as libraries which comprise textbooks, past thesis or project works, various internet sources, and other related works. The aim of the researcher for using this broad data collection method was to have a varse knowledge of the system, know what work has been done so far, and make necessary inputs and contributions to knowledge.

Data source/collection: Google.com,Youtube.com; Review of previous work; Park Lane Hospital, Enugu; Annunciation Hospital, Emene; Fine Brothers Electronics, Enugu; PRODA, Enugu.

The Block diagram and Schematic Circuit diagram of the system are shown in the figures below.

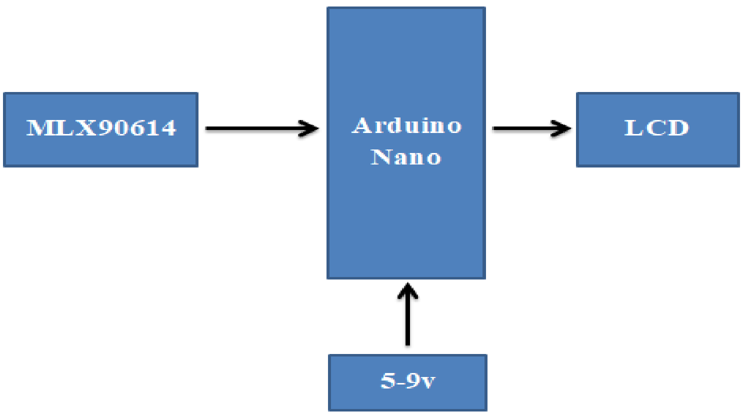

Figure 1: Block Diagram of the System

From the block diagram shown in figure 3.1 above, the Arduino Nano serves as the Microcontroller, which controls and coordinates the activities of the MLX90614 Non-Contact Temperature Sensor Module and the 1602 LCD Display connected to it. We have powered this Arduino Nano from an external 5-9V DC source through its Vin pin to make it a stand-alone system.

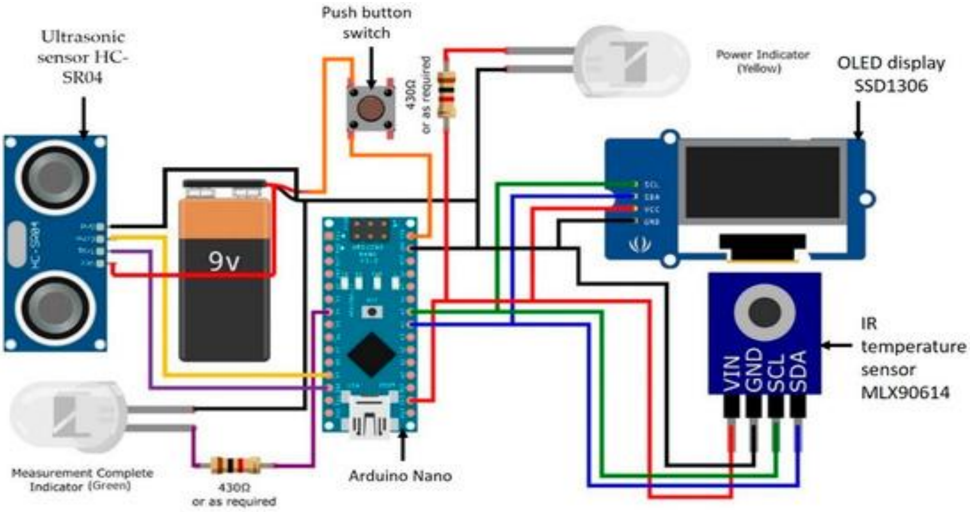

Figure 2: A Schematic Circuit Diagram of the System

From the Schematic Circuit Diagram above, the 5-9V battery provides power to the circuit which supplied to the Arduino Nano and other connected components (e.g., sensors, display). Arduino Nano serves (as the Microcontroller, which control and coordinates the activities of the **MLX90614 Non-Contact Temperature Sensor** and the 1602 LCD screen connected to it) as the brain of the system. It reads sensor data, processes it, and outputs results to the display and indicators. It connects to the infrared temperature sensor, ultrasonic sensor, LCD display, and other components to manage input/output operations.

The MLX90614 IR Temperature Sensor measures the temperature of a person without contact. Then, there is communication between the sensor and the Arduino through I²C protocol (using the SDA and SCL pins). When a person is in front of the sensor, it detects its temperature and sends the data to the Arduino for processing. The Ultrasonic Sensor (HC-SR04 is used for proximity detection to determine when a person's forehead is in the correct range for temperature measurement. It sends ultrasonic pulses and measures the time it would take for the echo to return, allowing the Arduino to calculate the distance. If a body is within required range, the Arduino triggers the temperature reading process. A push button switch is connected to manually trigger the temperature measurement process. When the button is pressed, the Arduino initiates the reading from the IR sensor. The 1602 LCD Screen shows the temperature reading obtained from the MLX90614 sensor. It connects to the Arduino via I²C communication (SDA and SCL lines). The display ensures that the user can easily see the measured temperature in real time.

Arduino Nano Development Board

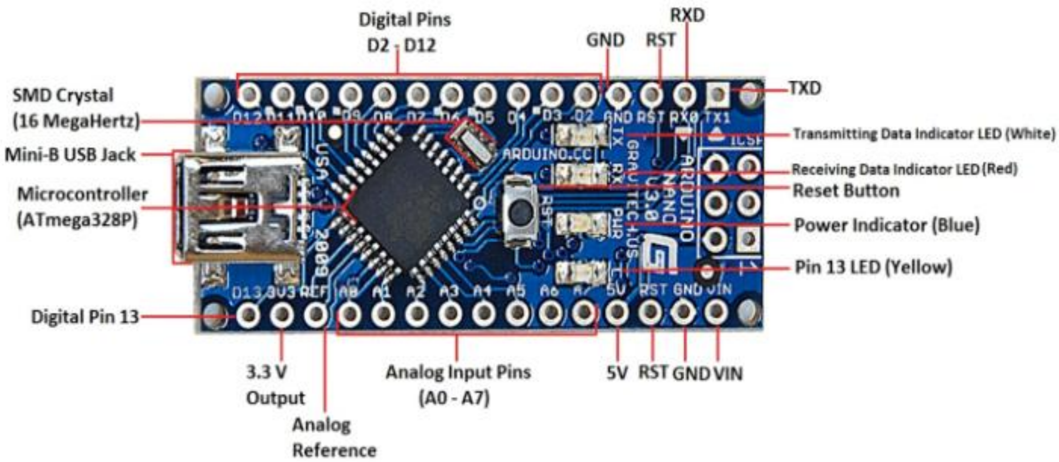

Figure 3. Arduino Nano Development Board

The Arduino Nano is Arduino's standard, responsive, designed board with the minimum dimensions. The Arduino Nano possesses pin headers that allow for ease of attachment onto a breadboard and features a Mini-B USB connector. The archetypal Nano is the oldest associate of the Arduino Nano family boards. The Arduino Nano Development Board was used in this project as a Microcontroller to coordinate and regulate the activities of the components that made up the system. It also processes the information obtained by the Temperature Sensor Module, and displays it on the LCD screen.

This Arduino Nano was powered through a 5-9 V rechargeable DC source to make the system a stand-alone. It has 14 Digital Pins and 5 Analog Pins, and can easily be programmed using Arduino IDE. However, appropriate Port (depending on your laptop) and Board (Nano) must be selected before uploading the code to this Arduino Nano; else you will get errors.

The code was written in Arduino IDE, which can be downloaded from the official Arduino website, arduino.cc. The language used in the coding was C++. After writing the code, the code was debugged and verified, before it was uploaded into the Arduino Nano by using a Type B USB Cable after successfully installed all the required Libraries.

The Arduino Nano was powered by a 5 V DC supply through its Vin pin and GND pin to make it a stand-alone system.

The functionality of the E-M-D hardware is made effective by a software design that controls the embedded Arduino microcontroller. The Arduino Nano microcontroller featuring an ATmega328P processor, is programmed via the Arduino Integrated Development Environment (IDE)─ an open source platform primarily written mainly in java and processing for writing microcontroller codes, often referred to as “sketches”. Figure 5 displays a portion of the code within the IDE. The following characteristics below enhance the appeal of the Arduino Nano, making it a favoured choice among enthusiasts in for many in electronics, robotics, and automation.

Compact Design: The Arduino Nano is renowned for its small and compact dimension measuring about 18mm x 45mm. This allows it to fit perfectly into a variety of projects, making it an ideal for applications where size is a factor. It is worthy to note that its small size does not compromise its functionality, providing a powerful solution in a tiny package.

Ease of Use: Compatibility with the Arduino IDE provides a user-friendly experience with the Nano. With a wealth of support and community-driven resources available, beginners can quickly get started. The familiar environment allows for flawless development and experimentation.

Versatility: Offering a wide range of digital and analog pins, the Arduino Nano provides versatility in connecting various sensors, actuators, and other components. With 14 digital I/O pins and eight analog inputs, it can handle multiple tasks simultaneously, making it suitable for multifaceted projects.

Affordability: One of the major advantages of the Ardiuno Nano is its cost-effectiveness. Despite its strong capabilities, it comes at an affordable price point, making it easy for hobbyists, students, and professionals to use. It offers a cost-effective entry into the world of microcontrollers without compromising quality or performance.

Integration Capability: The Nano’s compact design and versatile pin configuration enable easy integration into various systems. Whether embedded in a permanent installation or used in temporary prototypes, its thoughtful design ensures smooth integration with negligible hassle.

- **LCD 1602 Screen**

LCD 1602, or 1602, a character-type Liquid Crystal Display, is a variety of dot matrix module that display letters, numbers, and characters. It composed of 5x7 or 5x11 dot matrix positions; each position can display one character. The LCD 1602 was infused in this project to display the writings of the MLX90414 Temperature Sensor Module. The acronym 'LCD' stands for Liquid Crystal Display - a technology that makes use of deflection of light on a quartz screen display to show texts.

Figure 4. LCD 1602 Screen with 12C

We have interfaced LCD display screen to the Arduino Nano in order to be able to visualize the output of the system since the output is completely digital. This LCD display was connected to the Arduino Nano through the use of I2C (Inter-Integrated Circuit). The benefit of using I2C is that we do not have to use any of the digital pins of the Arduino when interfacing the LCD screen to it, and this makes the connection very easy, saves the digital pins and reduces the number of lines and complexity of the coding. However, the use of I2C increases the cost of this project. **The LiquidCrystal_I2C.h Library and Wire.h Library were used to program this LCD 1602 Module.** LCDs are used to create what are considered to be the world's best display panels. When connecting the LCD to the Arduino Nano, the SDA and the SCL pins of the LCD screen were connected to the analog pins A4 and A5 of the Arduino. The 5 V and GND pins of the LCD display screen were also connected to the Arduino Nano 5 V and GND pins respectively.

This 1602 LCD Screen is one of our compact versions, ideal for small projects, wearables, and other portable applications. One can easily view its sharp blue graphics from a wide, 160-degree angle range. Additionally, it boasts low power consumption during regular operation. This module can only withstand extreme temperatures, functioning effectively in conditions ranging from -30 to 70 degrees Celsius. It supports IIC communication, and you can find map on the front of the attached breakout board.

V DC Source

Fig 5. DC power supply

A DC/DC power supply also known as a DC/DC Converter, uses DC voltage as its input as a substitute of AC voltage. The primary purpose of DC/DC power supplies is to provide a regulated voltage output for electronic and electric devices. Unlike AC voltage, DC voltage cannot be adjusted up or down using a transformer. DC power supply can be derived from an AC line. Most electrical and electronic circuits necessitate a consistent DC voltage source that is stable regardless of the variations in the input. Although DC batteries can be used as a power source, they tend to be costly requires replacement periodically. So, it is necessary to first convert an AC input into a DC voltage source and regulate it for this purpose.

Male and female Header Pins

Fig 6 Male / Female Pin Header Straight

This 60-pin connector features 2 rows of 30 pins, making it perfect for fast connections between variuos modules. The pin pitch is 2.54mm. The pins in a female header are usually longer than the male connectors. It is also possible to use female headers as jumper wire recipients. These female headers have a broader range of applications than the male or the metric versions. Male and female header connectors are used in electronic circuit and each pin being gold-plated to ensure optimal conductivity and resistance to oxidation.

Connecting Wires

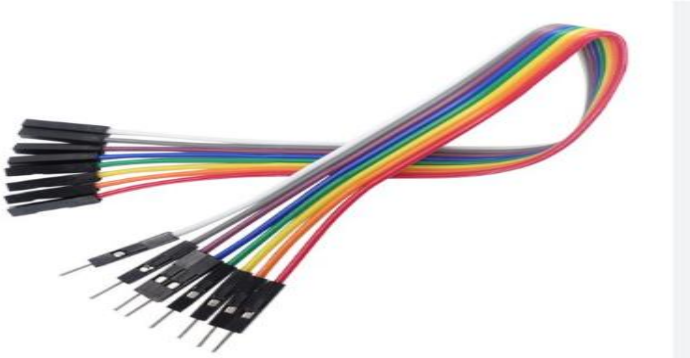

Fig 7 connecting wires

Wires can either be solid or stranded in structure. While most wires are round, there are seldom square or rectangular wires in use for integrated circuit external leads. Common metals used for wire production include aluminum, alloys, and copper. The insulation is typically made up of rubber or other non-conductive materials and is available in various sizes and colors.

Drilling Tools

Fig 8 Drilling Tools

This drill delivers a force of 442 inch-pounds allowing it to effortlessly tackle most tasks. It is capable of drilling 2-inch holes in wood and half-inch holes in metal. Featuring an ergonomic design, this power drill is favored among the cordless tools. This ergonomic design is what ensures that the drill is lightweight and evenly distributes weight above and below the grip, helping to reduce unnecessary strain or injury during use. It uses a half-inch keyless chuck, which is a convenient feature, as there is no need to worry about misplacing and replacing a key. The Bosch drill comes with two 18-volt lithium-ion batteries, which makes them lightweight, long-lasting, and as powerful as other battery types.

Soldering Iron and Soft Solder

Fig 9 Soldering Iron and Soft Solder

Solder on a Printed Circuit Board (PCB) can be thought of as a vital connective tissue. It functions as the conductive adhesive that glues components to substrate and maintains continuity throughout the circuit board. It's hard to envisage what modern electronics without this convenient, low-melting point alloy at our disposal.

Hot Gun

Fig 10 Hot Gun

Hot air guns are versatile tools that play a significant role in many types of work, from home improvement projects to industrial manufacturing processes. Industries such as aerospace, automotive, and boating rely heavily on these heavy-duty tools. Regardless of the application, safety awareness is crucial when using a power tool with a heated element. Heat guns are instrumental in building airplanes, and spacecraft for that matter. These electrically-heated power tools are particularly useful for a range of applications which includes heat shrinking, soldering, sealing, cauterizing, binding, shaping, and attaching various materials.

Table 1: Bill of Engineering Management

S/N	Quantity	Description	Unit Price()	Total Price()
1	**1**	**Temperature Sensor Module**	**N 5,000**	**N 5,000**
2	**1**	**Arduino Nano Development Board**	**N 2,500**	**N 2,500**
3	**1**	1602 LCD Screen	**N 600**	**N 600**
5	**2**	DC Source	**N 600**	**N 1,200**
6	**1**	Male and female Header	**N 300**	**N 300**
7	**3**	Connecting Wires	**N 250**	**N 750**
8	**2**	Patrax Sheet	**N 200**	**N 400**
9	**1**	Drilling Tools	**N 10,000**	**N 10,000**
10	**1**	Soldering Iron and Soft Solder	**N 12,000**	**N 12,000**
11	**1**	Hot Gun	**N 6,000**	**N 6,000**
12	**1**	Candle Gum	**N 1,000**	**N 1,000**
			=========	**N 39,750**

MLX90614 Non-Contact Temperature Sensor Module

MLX90614 is a temperature dimensioning device that functions with a infrared radiation phenomenon. It is best used used for applications that any form of contact is not required. This device features an infrared radiation-sensitive thermopile and an ASSP (Acoustics Speech and Signal Processing) integrated on the same TO-39 packaging. The MLX90614 is equipped with digital Pulse Width Modulation (PWM) and System Managing Bus (SMBus) interface, allowing for effective communication and data exchange.

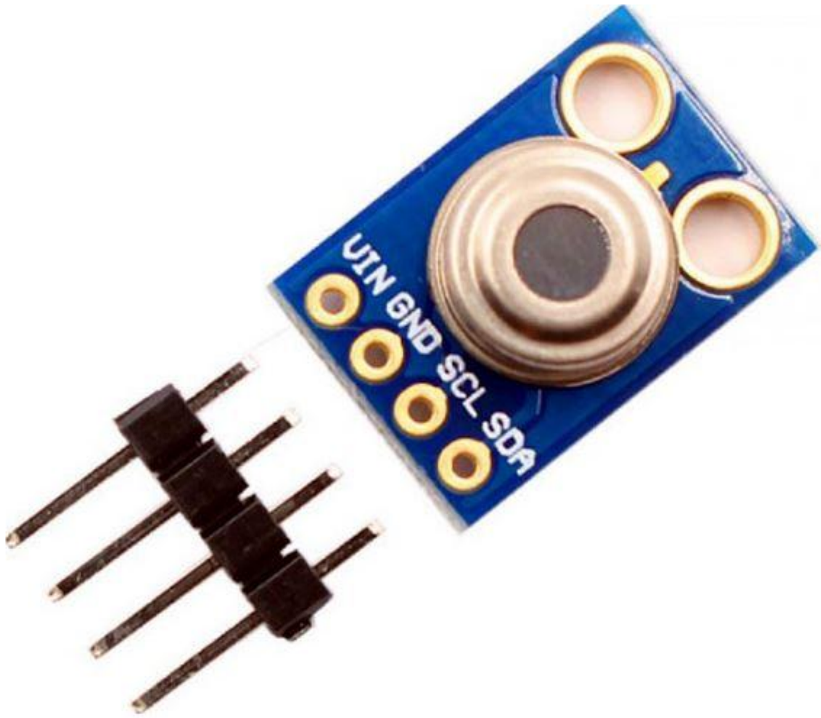

Figure 11 MLX90614 Non-Contact Temperature Sensor Module

The MLX90614 Non-Contact Temperature Sensor is utilized across different industries for measuring and controlling the temperatures of moving machine components and to read the body temperature OF individuals by merely coming close to them. **The** Adafruit_MLX90614.h Library was used in programming this MLX90614 Temperature Sensor Module.

- **Casing/Chassis**

Patrax were used to form a square-like container of dimensions 10 centimeter to house the entire components in order to protect them from moisture and dust. The components were glued into this Patrax box with candle gum through the use of Hot Gun. We have used some sets of Drilling Instruments to create holes on this Patrax box so that these components can fit properly into it.

The testing results shows that the system can effectively take the temperature of an individual (or any object) by merely coming closer to him without actually making contact, and display the reading in degree Celsius on a 1602 LCD Module that serves as our display unit here. Here, the user simply has to bring the thermometer close to the patient in order to read his body temperature without actually making contact. This thermometer can also be used to take the temperature of any object by merely coming close to it.

When compared with the standard and conventional thermometer found in the hospital, the system has reliability of above 90%. Majority of the components used in this project were bought from Jumia Online Stores, Konga Online Stores, and Fine Brothers Electronics, Enugu.

III. IMPLEMENTATION AND DISCUSSION OF RESULTS

The circuit was constructed in accordance with figure 3.2's circuit diagram, and all required connections were made and tested prior to the power supply being connected. All of the parts were meticulously placed inside the Patrax box and adhered using a hot gun. An analog switch was attached to the back of the system to ON and OFF it. When the system was ON, it took about 2 seconds to power. After these 2 seconds, the system will read and display the temperature of any object it comes close to (both human and non-human). The system will also display the temperature of its working environment to enable the user to make comparison. The system displays its temperature reading in degree Celsius. The entire system is contained inside a Patrax box and powered by a 5 V rechargeable DC source, and has reliability of above 98% when compared with the standard thermometers found in the hospitals.

The non-contact thermometer was successfully developed and tested under various conditions to evaluate its accuracy, response time, usability, and performance. Below are the results from the design and experimentation:

- **Temperature Measurement Accuracy:**

The device was validated against a standard mercury thermometer, and it achieved a temperature measurement accuracy of ±0.3°C. Table 1 presents a comparative analysis of readings obtained from the non-contact thermometer and a standard thermometer over a range of temperatures (35°C – 42°C).

Table 2: Comparison of Non-Contact Thermometer and Standard Thermometer Measurements

Temperature Source	Non-Contact Thermometer (°C)	Standard Thermometer	Difference (°C)
Patient 1	37.4	37.3	0.1
Patient 2	39.2	39.0	0.2
Patient 3	38.1	38.3	-0.2

- **Response Time:**

The device demonstrated a response time of less than 0.8 seconds, significantly faster than traditional contact thermometers, which require 30–60 seconds for readings. The fast response time ensures real-time monitoring, which is critical for screening in high-traffic areas during outbreaks.

- **Distance Accuracy Performance:**

Tests were conducted to determine the optimal range for non-contact measurement. The thermometer consistently provided accurate readings within 2–5 cm from the target, with accuracy decreasing slightly beyond this range.

- **Alarm System and Threshold Sensitivity:**

An alarm was integrated to trigger when temperatures exceeded 37.5°C, which is a preliminary indication of fever. In a test involving 50 subjects, the alarm correctly activated in 12 cases, correlating with known febrile conditions in these individuals.

- **Power Consumption and Portability:**

The device consumed minimal power, with a battery life of approximately 10 hours under continuous operation. It was lightweight and portable, making it suitable for use in remote areas or mobile screening units.

Prototype

(a)

(b)

(c) 

Figure 12a, b, & c: The device from when it is turned on to when it is placed over a forehead and reads both room temperature of 27.27^{o}C and body temperature of 37.0^{o}C

The system took roughly two seconds to power up when it was turned on. Following these two seconds, the system is prepared to read and show the temperature of any person that it approaches. It will do so on a 1602 LCD Module, which is our display unit. Since there is no need for physical contact and the thermometer is entirely digitalized, anyone without any kind of specialized training can read it with ease. Temperature readings are shown by the system in degrees Celsius. All of the components' actions were coordinated and managed by an Arduino Nano Development Board acting as a microcontroller. By bringing the device close to the body, it can efficiently read and display the body temperature.

IV. CONCLUSION.

By identifying the carrier early, quickly, and accurately, this system will significantly aid in the detection and containment of highly contagious diseases such as COVID-19 and Ebola. Furthermore, since no particular training is needed to operate the system, anyone can use it.

Therefore, the results from the experiments demonstrate that the non-contact thermometer is a reliable and effective tool for detecting early signs of life-threatening illnesses and infectious diseases by identifying elevated body temperatures**.** Since the thermometer does not require physical contact with patients, it minimizes the risk of cross-infection among individuals, making it ideal for use in high-risk environments such as hospitals, airports, and public gatherings. This is particularly crucial when there is a breakout of highly infectious diseases like COVID-19, Ebola, and Lassa fever. The fast response time of the device ensures that large numbers of people can be screened efficiently within a short period. This feature makes it highly applicable for mass screening scenarios during pandemics or outbreaks, reducing bottlenecks at checkpoints. While the device achieved a high degree of accuracy, certain limitations were observed. Environmental factors such as direct sunlight and air conditioning affected the readings slightly. Additionally, measurements taken from individuals wearing hats or scarves resulted in lower accuracy. Future versions could incorporate algorithms to correct for such external interferences. Although the alarm system correctly identified febrile conditions, there were occasional false alarms, especially in cases where individuals had just completed physical activities. This indicates that the threshold value for fever detection may need further refinement to distinguish between exertion-induced temperature rises and febrile conditions. The simplicity and portability of the device make it easy for non-specialists to operate, encouraging widespread adoption. Health officials, especially in resource-limited settings, can benefit from its lightweight design and long battery life. The integration of wireless communication for data logging in future models would enhance tracking and contact tracing efforts during disease outbreaks.

Moreover, deploying such devices across multiple locations can improve epidemiological data collection and support targeted public health responses. Testing and evaluation demonstrated that the thermometer delivers accurate results with a response time of less than 0.8 seconds, making it suitable for mass screening during outbreaks. It is lightweight, portable, and operates efficiently within a range of 2–5 cm. Although the thermometer performed reliably, certain environmental factors and activities, such as direct sunlight exposure or recent physical exertion, slightly affected its accuracy. The built-in alarm system functioned well in most cases but occasionally triggered false alerts. Overall, the device is a practical tool for early fever detection, which is crucial for frequent health monitoring and in controlling the spread of infectious diseases.

The coding was done in Arduino IDE which was downloaded from arduino.cc which is the official website of the Arduino. Prior to uploading the sketch, the required libraries must be installed, unless in the case of recurrent error messages during compilation.

RECOMMENDATION

Based on the findings from this project, the following recommendations are suggested:

1. Environmental Calibration and Algorithm Improvement: Future versions of the thermometer should incorporate algorithms to compensate for external factors such as sunlight, air conditioning, and recent physical activity to enhance accuracy.
2. Integration with Digital Systems: Adding wireless communication features (e.g., Bluetooth or Wi-Fi) would allow the device to transmit temperature data to a central database for real-time monitoring and epidemiological analysis. This would improve contact tracing and outbreak management efforts.
3. Adjustable Fever Threshold: To reduce false alarms, the device should allow for the customization of fever thresholds based on user preferences or environmental conditions, ensuring more reliable detection.
4. Battery Optimization and Solar Charging: The battery life can be extended through more efficient power management, and integrating solar charging would make the device more suitable for remote and resource-constrained areas.
5. Field Testing and Mass Production: Further field trials are recommended to test the thermometer’s performance in diverse environments and on larger populations. If successful, efforts should be made to scale up production and distribute the device to hospitals, airports, and public spaces where frequent checkup is critical.

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