Design And Development Contactless Temperature Scanner with Voice Output

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ABSTRACT- Recent developments in healthcare technology have witnessed a growing need for the development of automated and contactless temperature monitoring systems to ensure public health safety. Body temperature is an essential physiological parameter used for the early diagnosis of infections and diseases. Traditional temperature measurement methods are often contact-based or require close interaction, thus increasing the chances of cross-contamination and lowering efficiency in a crowded setting. This paper reviews the development of contactless temperature monitoring systems using infrared sensors, embedded systems, and Internet of Things (IoT) technology. Different research works are examined and compared based on parameters such as accuracy, response time, automation ability, cost, and usability. The paper reveals the growing need for technological advancements in the development of efficient, reliable, and safe temperature monitoring systems in public health settings through the integration of infrared sensing technology with embedded systems and automation technology.

Key Words: Contactless Temperature Measurement, Internet of Things (IoT), Infrared Sensor, Voice Output System, Healthcare Monitoring, Embedded Systems, Smart Health

1. INTRODUCTION

Embedded systems and IoT technologies have completely changed the way we monitor our health. Modern intelligent health monitoring systems enable us to remotely gather, process, and analyze health information, thus accelerating medical responses and preventing diseases. Among the most important parameters to monitor is the body temperature. It is particularly important for diagnosing infections and is a critical parameter during outbreaks of contagious diseases. For this reason, efficient and hygienic temperature screening systems are increasingly in high demand.

Conventional thermometers, whether mercury or digital contact thermometers, require direct contact, which increases the risk of infection and is not very suitable for mass screening. Even handheld infrared thermometers require an operator, which is not very efficient in busy environments. It is for this reason that contactless temperature monitoring systems have emerged as a fast, safe, and automated screening solution.

Infrared temperature sensing is a good way to measure the heat emitted by the body. When combined with embedded systems and IoT technology, these sensors can be used to make smart monitoring systems that can make fast decisions and exchange information. However, most of these systems today are only capable of displaying information on a screen or sending notifications to mobile phones, which may not be easily accessible. The Contactless Temperature Scanner with Voice Output is an improvement over these systems because it provides auditory feedback that immediately announces the temperature. This is particularly useful in noisy or busy environments where people cannot take the time to read information from screens. Additionally, with the use of IoT technology, temperature information can be recorded, analyzed, and monitored from a distance, which can help authorities make fast preventive measures. This paper provides a comprehensive review and analysis of the proposed system, including its design, development, and potential use in ensuring public health safety.

2. PROBLEM STATEMENT

Accurate and rapid body temperature measurement is crucial to early detection of contagious diseases and maintaining public health safety, particularly in public areas such as hospitals, airports, schools, and offices. Conventional approaches such as contact thermometers and manually operated infrared scanners have the disadvantage of requiring physical contact with individuals or the need for a human operator to operate the device. This increases the risk of infection, is time-consuming, and not suitable for mass screening.

Recently, there has been interest in the development of contactless body temperature measurement systems based on infrared sensors, embedded systems, and Internet of Things concepts. However, these systems are highly diverse in terms of their architecture, cost, accuracy, level of automation, and usability. Most of these systems are not fully automated, do not provide real-time feedback, or are not cost-effective. Some require a constant internet connection or are based on complicated hardware configurations.

This situation clearly indicates the need for a systematic analysis and comparison of existing contactless body temperature measurement systems to identify their characteristics, limitations, and research gaps. A comprehensive analysis will enable us to understand the current trends in the technology, the effectiveness of different approaches, and areas for improvement in contactless health monitoring in the future.

3. LITERATURE SURVEY

A series of research studies focuses on non-contact monitoring and automated screening by infrared sensing and other technologies, each with its own trade-offs and advantages.

3.1 Patil et al. (2020) developed a non-contact temperature measurement system using an infrared sensor and a microcontroller. The system accurately measures temperatures without physical contact, but it lacks automated user feedback.
3.2 Kumar and Sharma (2021) developed an IoT-based health monitoring system that integrates temperature and heart rate measurement. The system allows remote data observation, but it requires a constant internet connection, which adds complexity and makes it non-portable.

3.3 Raj and Bhatia (2022) developed an automated entry screening system that integrates infrared sensing and proximity sensing. The system enhances automated screening but only provides visual display output, which is not accessible.

3.4 Singh et al. (2023) developed a temperature monitoring system on a high-performance computing platform with centralized data storage. The system processes data in a sophisticated manner but increases costs and computational complexity.

3.5 Alim et al. (2020) developed a smart health monitoring system that incorporates wireless transmission modules for real-time monitoring. The system is useful for hospitals but requires multiple hardware components, which increases implementation complexity.

3.6 Divyasudha et al. (2019) developed an IoT-based safety monitoring system that demonstrates the cost-effective integration of sensors. Although the system is designed for safety applications, it also indicates the possibility of developing health monitoring systems.

In summary, the series of research studies demonstrates a common use of infrared sensing due to its accuracy and non-contact measurement capability. However, many of the systems lack automation, real-time feedback, and cost-effectiveness, which are areas of innovation.

COMPARATIVE ANALYSIS OF EXISTING SYSTEMS

To better understand the limitations of existing contactless temperature monitoring systems, a comparative study was conducted based on key performance parameters such as sensing technology, automation capability, feedback mechanism, IoT integration, and system complexity. The comparison highlights that although infrared sensing technology is widely adopted due to its accuracy and non-contact capability, most systems lack accessibility features such as voice feedback and full automation.

Many of the reviewed systems rely solely on visual display output, which may not be suitable in crowded or fast-moving public environments. Additionally, several IoT-based systems require continuous internet connectivity, increasing power consumption and system complexity. The proposed system improves upon these limitations by integrating automated human detection and a voice output module while maintaining a cost-effective and compact design.

4. METHODOLOGY

This review is based on a systematic literature analysis to identify research on contactless temperature monitoring systems using infrared sensing, embedded systems, and IoT solutions. It collected relevant articles from academic journals, conference proceedings, and reputable scholarly databases. The criteria for selection were biased towards recent research work on non-contact temperature measurement, automated screening, and smart healthcare monitoring.

The articles were filtered based on relevance, technical value, and the completeness of experimental validation. Articles that did not have a clear methodology, performance analysis, or technical description were discarded to maintain the validity of the analysis. Each selected article was analyzed and categorized based on key technical parameters such as the sensing technology, processing hardware, level of automation, accuracy of the system, cost-effectiveness, and application domain.

A comparative analysis was conducted after categorization to identify similarities, differences, advantages, and disadvantages among the reviewed systems. The review analyzed design trends, sensor technologies, and implementation strategies to understand the current state of the art in contactless temperature monitoring research. Based on this analysis, the gaps in the literature and future research directions were identified to highlight areas where further research is required.

5. PROPOSED SYSTEM ARCHITECTURE

The architecture of a contactless temperature monitoring system with voice output typically consists of an infrared temperature sensing unit, a microcontroller-based processing unit, a human presence detection module, and an audio feedback system. Optional IoT connectivity may also be integrated for remote monitoring and data storage.

In the proposed framework, the MLX90614 infrared temperature sensor is widely adopted for non-contact temperature measurement due to its high accuracy and fast response time. The sensor communicates with a microcontroller such as ESP32 through the I2C protocol for data acquisition and processing.

To enable fully automatic operation, an ultrasonic sensor such as HC-SR04 can be integrated for human presence detection. The ultrasonic module detects an object within a predefined range and triggers the temperature measurement process without requiring physical interaction.

The processing unit, generally an ESP32 or Arduino-based controller, performs real-time data acquisition, threshold comparison, and decision-making. When the measured temperature exceeds a predefined limit (for example, 37.5°C), an alert condition is generated.

For improved accessibility and usability, a voice output module such as the DFPlayer Mini may be incorporated. The audio module plays pre-recorded voice messages stored on a microSD card, providing immediate auditory feedback. This feature enhances system effectiveness in public environments where visual display alone may not be sufficient.

The overall architecture ensures:

- Fully contactless operation
- Automated detection and measurement
- Real-time processing
- Voice-based alert mechanism
- Optional cloud connectivity for remote data logging

In systems integrated with IoT capabilities, temperature data can be transmitted via Wi-Fi to a cloud platform for centralized monitoring and analysis. This supports large-scale deployment in hospitals, educational institutions, airports, and other public facilities. The architectural design emphasizes simplicity, cost-effectiveness, automation, and accessibility while maintaining measurement accuracy and operational reliability.

5.1 Selecting and Preparing the Components

The processing unit of contactless temperature monitoring systems typically consists of a microcontroller such as ESP32 or Arduino due to their processing capability and integrated communication features. The MLX90614 infrared sensor is widely used for non-contact temperature measurement because of its high accuracy and fast response time.

5.2 Creating the Circuit

With parts verified, the following was an approximation of how the hardware wiring came together:

- MLX90614 connected with ESP32 via I2C [SDA and SCL].
- HC-SR04 hooked up to the digital GPIO pins for its trigger and echo.
- DFPlayer Mini connected, via serial, to the ESP32 (TX and RX).

Audio by a mini speaker attached to the DFPlayer Mini. A microSD card inserted into the DFPlayer for holding pre-recorded audio. A regulated power supply used for keeping voltage steady.Voltage levels and appropriate grounding had been carefully attended to, which helped prevent damage.

5.4 Software Development

1. Firmware was written in the Arduino IDE using the ESP32 setup. The flow of the program was laid out as

2. Initialize sensors and communication channels: I2C and Serial.

3. Distance continuously using the HC-SR04.

4. When there is a person within a set range, about 5 to 10 cm, it will begin reading the temperature.

5. Get the temperature data from the MLX90614.

6. Threshold comparison was performed for readings above approximately 37.5°C.

If normal, then play the audio for "Normal Temperature"; if high, then play the "High Temperature Warning" audio; reset and wait for the next user.

This code was tuned to cut response time and improve measurement stability. 6.4 Creating the Audio Files Voice messages were pre-recorded in MP3 format, stored on the microSD card, and numbered to correspond with the naming convention that the DFPlayer Mini expects. Recordings should also be clear and straightforward to understand.

5.5 System Testing and Calibration

After assembly, the system was tested under various conditions, including different ambient temperatures, varying distances, and multiple users. The system was set to calibrate and ensure precise temperature readings. The ultrasonic detection range was also adjusted to prevent false positives. The system’s response time was within a few seconds, which are considered real-time.

5.6 Final Deployment Setup

We then encased the entire system in housing, which was meant to protect the electrical devices. The system also ensured the temperature sensor was facing outwards for accurate reading. Finally, it was tested in a public environment simulation.

6. RESULTS

The developed system was tested under various environmental and operational conditions to evaluate its performance and reliability. Temperature readings were compared with a standard digital thermometer to assess accuracy.

The system demonstrated an average accuracy deviation of ±0.3°C under normal indoor conditions. The response time of the system was approximately 2–3 seconds from detection to audio output, which is considered suitable for real-time public screening applications.

The ultrasonic sensor effectively detected human presence within a range of 5–10 cm, ensuring fully automated operation without physical contact. The voice output module successfully delivered clear audio feedback, enhancing usability especially in crowded environments.

However, slight variations in readings were observed under extreme ambient temperature conditions, which indicates the need for calibration improvements in future versions. Overall, the system performed efficiently and achieved its objective of providing safe, contactless, and automated temperature monitoring.

6.1 Response Time

The total time taken from human detection to voice output announcement was measured.

- Ultrasonic detection time: ~0.5 seconds
- Temperature acquisition time: ~1 second
- Audio playback trigger time: ~1 second

Total Response Time: 2–3 seconds

6.2 Output Behaviour

For Normal Temperature (Below 37.5°C)

When the measured temperature is below 37.5°C:

- The system displays the temperature on serial monitor or display.
- The DFPlayer Mini plays the pre-recorded message: "Your temperature is normal**."**

For High Temperature (Above 37.5°C)

When the measured temperature exceeds 37.5°C:

- The system triggers alert condition.
- The speaker outputs: "Warning! High temperature detected."

6.3 Automation Performance

- The HC-SR04 ultrasonic sensor successfully detected human presence within 5–10 cm range.
- No physical contact was required.
- False triggering was minimal after calibration.
- System automatically resets after each reading.

6.4 Environmental Impact Observation

Under extreme ambient temperature conditions:

- Slight variations (±0.3°C to ±0.4°C) were observed.
- Direct sunlight exposure affected accuracy.
- Indoor controlled environment produced stable results.

7. FUTURE SCOPE

Future advancements in contactless health monitoring systems can focus on integrating artificial intelligence algorithms for anomaly detection and predictive health analysis. Machine learning techniques can be used to identify abnormal temperature patterns and trigger automated alerts.

Cloud-based data analytics platforms can be incorporated for centralized monitoring across multiple deployment locations. This would enable authorities to track trends and take preventive action during disease outbreaks.

Edge computing technology may also be implemented to reduce latency and improve real-time processing capabilities. Furthermore, integration of additional physiological sensors such as heart rate and oxygen saturation sensors can transform the system into a multi-parameter health screening device.

Improved environmental calibration algorithms and thermal compensation techniques can enhance measurement accuracy in varying weather conditions.

8. CONCLUSION:

The Contactless Temperature Scanner with Voice Output is an ESP32-based, practical, and hygienic approach for automatic temperature screening. The MLX90614 infrared sensor provides accurate contactless measurement, while the HC-SR04 ultrasonic sensor allows fully autonomous detection of a target without requiring user interactions or any physical touch. The addition of the DFPlayer Mini audio module provides immediate feedback through voice and adds to the system's accessibility in use in public places.

The use case guarantees an effective operation in real-time, with response times being fast and performance stability in regular conditions. The ESP32 provides for good processing, low power consumption, and upgrade capabilities in the future. Compared to traditional manual thermometers, this solution minimizes the risk of infection, accelerates screening, and decreases dependence on human labour.

In summary, the prototype is cost-effective, compact, and scalable enough to be deployed in hospitals, schools, offices, and other public areas. It thus points out how much embedded systems and sensor integration can meaningfully contribute to both public health monitoring and safety.

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