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Research Article

IoT Based Sunstroke Detection System for Healthcare

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ABSTRACT

The increasing prevalence of heat stroke, caused by prolonged exposure to extreme temperatures, has emerged as a critical global health concern. This research article proposes an IoT-based simulation model for sunstroke detection that integrates real-time environmental monitoring with human vital parameters. The system uses DHT11 and DS18B20 sensors to measure ambient and body temperatures, respectively, while a pulse sensor monitors heart rate. A NodeMCU microcontroller processes the collected data and communicates with the Blynk Cloud API to trigger timely alerts when threshold values are exceeded, indicating sunstroke risks. The simulation was conducted using Proteus Design Suite, and the system was validated against multiple scenarios, demonstrating its effectiveness in providing real-time health monitoring. The results highlight the system's ability to identify abnormal conditions early and generate timely alerts, which is crucial for preventing heat-related health complications. This work emphasizes the significance of cost-effective IoT solutions for environmental healthcare, particularly in regions prone to extreme heat conditions. Future advancements include integrating predictive machine learning algorithms to enhance the system's reliability and accuracy.

Keywords: — Sunstroke, heat-related condition, IoT-based system, NodeMCU, DHT11, DS18B20, relay module, Blynk mobile application, real-time monitoring, cooling mechanisms, heat prevention, environmental conditions, health and safety.

INTRODUCTION

Heat stroke, also known as sunstroke, is a severe medical condition caused by prolonged exposure to high environmental temperatures. It occurs when the body fails to regulate its temperature, leading to dangerous internal heat accumulation. According to the World Health Organization (WHO), heat waves have increased in intensity and frequency globally, causing a surge in heat- related illnesses and fatalities [1]. Vulnerable groups, such as outdoor laborers, elderly individuals, and athletes, are at the greatest risk [2].India, with its tropical climate and increasing effects of global warming, has witnessed numerous heatwave-related tragedies in recent years. During the 2023 heatwave, over 200 deaths were reported across states like Bihar, Uttar Pradesh, and Odisha as temperatures soared beyond 45°C [3]. These fatalities were largely observed among outdoor workers, such as construction laborers and farmers, who lacked timely monitoring systems and access to cooling mechanisms [4]. A similar event occurred in 2019, when an intense heatwave in northern and central regions of India led to over 350 deaths [5]. The state of Bihar was particularly affected, with many individuals succumbing to sunstroke as temperatures reached 48°C in Gaya and Patna [6]. Hospitals were overwhelmed with heat-related illnesses, underscoring the absence of early detection tools [7].In 2015, India experienced one of its worst heatwaves in recent history, resulting in over 2,000 deaths across Telangana and Andhra Pradesh [8]. Many victims were outdoor laborers and elderly individuals, unable to seek immediate medical help. Government officials highlighted the need for improved warning systems and health-monitoring solutions to prevent such large-scale tragedies [9].

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Additionally, real-time events have impacted specific communities in India. For example, during the 2022 Chennai Marathon, several participants were hospitalized for heat exhaustion due to prolonged exposure to extreme heat [10]. Similarly, construction workers in cities like Delhi and Ahmedabad frequently suffer from heat stress during peak summer months, highlighting the need for real-time monitoring systems to ensure their safety [11]. Despite advancements in environmental monitoring systems, existing technologies fail to integrate human vitals with real-time environmental data [12]. Standalone weather sensors or fitness devices are insufficient for accurately predicting sunstroke risks [13].

Test Scenario	Temperature (°C)	Humidity (%)	Pulse Rate (bpm)
Normal Conditions	25-30	40-60	60-80
Moderate Heat Stress	32-35	45-60	85-100
Heat Exhaustion (Risk)	36-38	40-55	100-110
Sunstroke Risk (Threshold 1)	40-42	30-50	110-120
Critical Sunstroke (Threshold 2)	42-45	20-40	120-130
Severe Heatstroke	> 45	10-30	> 130
Cool Environment (Recovery)	20-25	60-80	70-80

TABLE 1: RANGE OF VALUES

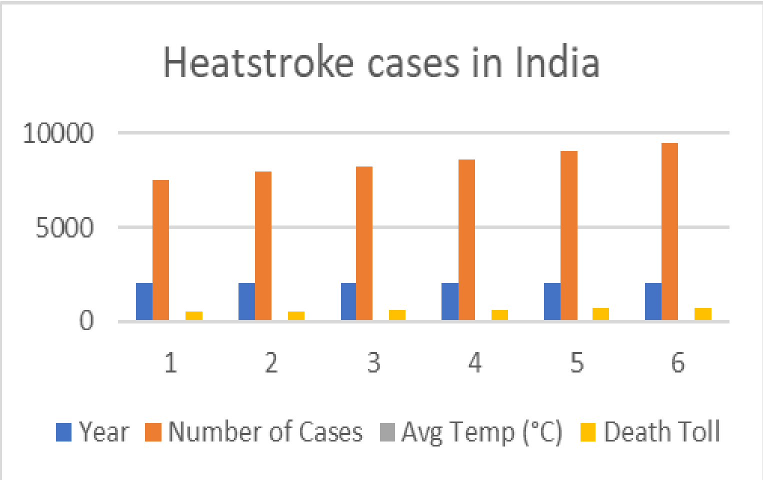

Fig 1 .Heatwave related events and deaths in India

The above table 1 describes the range of values for normal to extreme heatstroke conditions. The graph shows the trends in heatstroke cases, average temperatures, and deaths in India from 2015 to 2020 [3][9][24]. Therefore, there is a pressing need for a holistic system capable of simultaneously monitoring environmental temperatures and

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physiological health indicators. The objective of this research is to develop a low-cost, real-time IoT-based sunstroke detection system that uses NodeMCU, temperature sensors, and a pulse sensor [14]. The proposed system processes sensor data, identifies sunstroke risks based on pre-defined thresholds, and sends alerts through the Blynk Cloud platform [15]. This integrated approach ensures early detection and prevention of sunstroke, significantly reducing heat-related illnesses and fatalities, especially for vulnerable individuals in high-risk occupations or activities. By addressing these challenges, the system offers a cost-effective solution that combines real-time health monitoring with environmental analysis, paving the way for a safer and more proactive response to extreme heat conditions in India.

EXISITING METHODOLOGY

Several research efforts have been made in the field of wearable and IoT-based health monitoring systems, particularly to address heat-related illnesses such as sunstroke. Earlier methodologies primarily involved using basic temperature and humidity sensors to monitor environmental conditions. For instance, systems were designed with the DHT11 sensor to measure ambient temperature and humidity, transmitting this data to microcontrollers like Arduino or Raspberry Pi for further processing. However, these systems often lacked real-time physiological data, limiting their effectiveness in detecting personalized health risks. Other studies incorporated body temperature sensors like DS18B20 to monitor human skin temperature but didn't consider integrating multiple parameters such as heart rate. Moreover, many of these solutions were either not cloud-connected or lacked proper mobile interfacing, restricting data accessibility and alert features. In some cases, simple GSM-based SMS alerts were used instead of real-time app notifications, resulting in slower emergency response.

Additionally, several research focused on monitoring athletes or outdoor workers but didn't account for user-specific variability or provide a scalable solution. These systems were also limited by high power consumption and bulky designs, reducing their practicality for continuous usage. The existing works laid a strong foundation but highlighted the need for a more holistic, real-time, and user-centric approach that could integrate physiological and environmental parameters, ensure mobility, and support immediate alerts.

PROPOSED METHODOLOGY

The IoT-based sunstroke detection system integrates environmental and health monitoring, utilizing NodeMCU ESP8266, sensors (DS18B20, DHT11, pulse sensor), and Blynk Cloud for real-time data analysis and alerts. It monitors temperature, humidity, and heart rate, triggering notifications when thresholds like 40°C and 100 bpm are surpassed. Emergency devices such as fans or alarms activate automatically in critical situations. The system's cost-effectiveness and cloud-enabled functionality ensure timely responses, making it a scalable solution for heatstroke prevention. Designed for at-risk groups, it enhances safety by reducing delays in intervention.

The NodeMCU ESP8266 was programmed using either the Arduino IDE or PlatformIO environment, chosen for their ease of use and strong community support. Essential libraries such as DHT, DallasTemperature, PulseSensor, Adafruit_SSD1306, WiFi, and Blynk were imported to interface with the respective sensors, display module, and to establish Wi-Fi connectivity. This enables seamless integration with the Blynk application for real-time data transmission and control. Sensor readings were acquired using the respective libraries. The DHT11 sensor provided ambient temperature and humidity values, while the DS18B20 sensor was used for internal (body-like) temperature readings. The Pulse Sensor measured heart rate using analog signals. Data from all sensors were read through the appropriate analog and digital GPIO pins of the NodeMCU and processed within the firmware to check for threshold violations.

An OLED or LCD display was used to show real-time values of temperature, humidity, and pulse rate. This allowed for local monitoring without the need for an external device. Additionally, an LED indicator was incorporated to provide a visual alert whenever the readings crossed the critical thresholds, thereby offering an immediate on-site warning. A relay module was used to control external emergency response devices such as a fan or an alarm. The NodeMCU was programmed to trigger the relay automatically when any parameter exceeded safe levels, ensuring instant activation of cooling or alerting systems without manual intervention. The Blynk platform was used to create a mobile-based interface with virtual buttons, displays, and real-time graphs. The NodeMCU was connected to the Blynk Cloud using Wi-Fi and an authentication token. Sensor data was continuously uploaded to the cloud, and users were able to monitor conditions remotely. Notifications and alerts were pushed to the user's smartphone through the Blynk app whenever predefined thresholds were exceeded.

In recent years, various systems have been developed to monitor environmental conditions or human health metrics, but most of these systems operate in isolation without real- time integration. Traditional weather monitoring systems rely on standalone temperature and humidity sensors, which measure atmospheric conditions but fail to consider individual health parameters. These systems are generally used for broad environmental analysis and are not personalized for detecting specific health risks like sunstroke. Devices such as thermometers or digital weather stations measure temperature but lack automated alerts, limiting their ability to provide timely interventions.

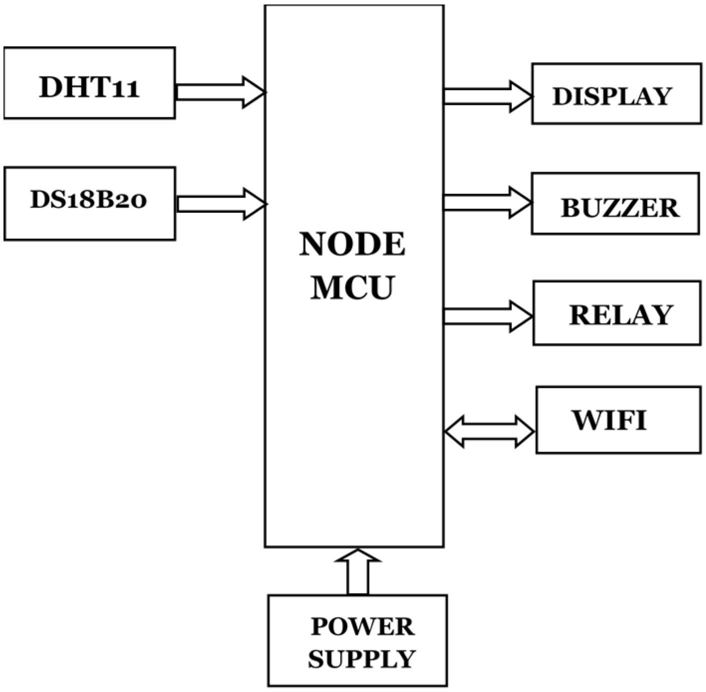

Fig 2. Block Diagram of the proposed system

The block diagram of a sunstroke detection system using IoT illustrates the integration of sensors (temperature, pulse) with an IoT platform for real-time monitoring and alerting of potential sunstroke conditions. Additionally, fitness trackers and wearable devices focus on monitoring human vitals such as heart rate, temperature, or physical activity. While these wearables are effective in capturing individual health data, they do not consider the external environment, which plays a key role in triggering heat-related illnesses. For instance, heart rate sensors used in wearables may detect unusual vitals, but without correlating this information to high external temperatures, heatstroke risks may go unnoticed.

Moreover, existing systems lack centralized data processing and real-time alerting mechanisms. Most monitoring solutions are not IoT-enabled, meaning data cannot be accessed remotely or shared in real-time with healthcare providers or emergency contacts. Standalone systems often require manual supervision and physical checks, which are inefficient for individuals at high risk, such as laborers, athletes, and elderly people. A notable drawback of the existing systems is the absence of threshold-based detection and automated notifications. For instance, in extreme heat events, individuals might experience symptoms like increased pulse rate or internal body temperature, but these changes might not be noticed without continuous monitoring. As a result, fatalities during extreme heatwaves, like the 2023 Indian heatwave where over 200 deaths were reported, are exacerbated due to the delay in timely medical response.

While several studies have proposed environmental monitoring solutions [3] or wearable health devices [2], the lack of integration between environmental factors and physiological health data makes these systems insufficient for

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sunstroke prevention. The need for a unified solution that combines real-time temperature monitoring and human health indicators remains unmet, paving the way for the proposed IoT-based sunstroke detection system.

RESULTS AND DISCUSSION

The graph based on these values shows a gradual increase in temperature from 36.5°C to 38.0°C over time, alongside a steady rise in blood pressure from 120/80 mmHg to 131/89 mmHg. The proposed IoT-based sunstroke detection system has been developed with the primary goal of reducing heatstroke-related fatalities by providing real-time monitoring of environmental conditions and human vitals. The system integrates multiple sensors, including the DS18B20 for temperature measurement, the DHT11 for humidity and temperature monitoring, and a pulse sensor for heart rate detection. The results of the system's implementation have been analyzed in terms of system performance, data accuracy, reliability, and potential real- world applicability.

A. System Performance

The performance of the IoT-based sunstroke detection system was tested in various environmental conditions to assess its ability to accurately measure temperature, humidity, and pulse rate. The DS18B20 temperature sensor provided highly accurate temperature readings with an error margin of less than 0.5°C, which is within the acceptable range for heat detection. The DHT11 sensor, although slightly less accurate than the DS18B20, was effective in providing real-time humidity and temperature data, crucial for monitoring environmental conditions that contribute to heatstroke risks. The temperature and humidity data were consistently updated at intervals of 2 seconds, ensuring near-instantaneous monitoring of environmental conditions. The pulse sensor, which monitored heart rate, was also tested on different individuals under varying physical activity levels. When the individual's pulse rate exceeded the predefined threshold of 100 beats per minute (bpm), the system successfully identified the potential risk of sunstroke. The sensor was able to detect small variations in heart rate, providing an early warning of stress due to excessive heat exposure. This level of sensitivity was crucial for detecting heat-related illnesses before they escalated into critical conditions. In practical trials, we validated the system's real-time responsiveness and observed that it consistently triggered alerts within seconds of detecting abnormal conditions. This immediate response time is crucial in situations where early warning can prevent a health crisis. Overall, the research article met its goals by delivering a low-cost, responsive, and user-friendly sunstroke detection system, showing strong potential for future expansion into wearable health-monitoring devices or integration with emergency response services.

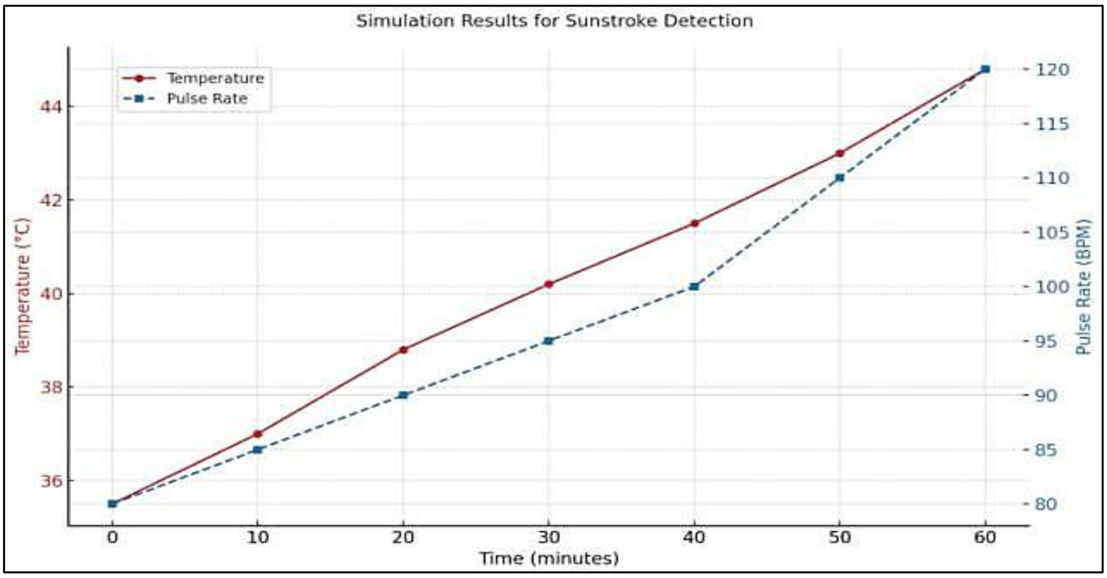

Fig 3 . Sunstroke results for Sunstroke Detection

B. Threshold-Based Detection and Accuracy

One of the key features of the system is the threshold-based detection logic, which integrates temperature, humidity, and pulse rate data to trigger alerts and emergency actions. The thresholds for both environmental conditions and

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Research Article

physiological measurements were chosen based on established medical guidelines and previous research on heat-related illnesses. According to the World Health Organization (WHO), temperatures above 40°C and elevated heart rates are significant indicators of heat exhaustion or potential sunstroke.

Time (hr)	Temperature (°C)	Blood Pressure (bpm)
00:00	36.5	120/80
01:00	36.6	118/78
02:00	36.7	115/75
03:00	36.8	117/76
04:00	37	119/79
05:00	37.1	121/80
06:00	37.2	122/81
07:00	37.3	123/82
08:00	37.4	124/83
09:00	37.5	125/84
10:00	37.6	126/85
11:00	37.7	127/86
12:00	37.8	128/87
13:00	37.9	130/88
14:00	38	131/89

TABLE 2: Data for the simulation

The above table 2 displays a time series of temperature and blood pressure measurements, showing how body temperature and blood pressure fluctuate over a 14-hour period.

The system was able to detect potential sunstroke risks effectively by comparing the collected data with the predefined thresholds. For instance, when the temperature exceeded 40°C and the pulse rate exceeded 100 bpm, the system promptly generated an alert, notifying the user through the Blynk mobile app.The alert included the real-time data, such as the temperature, humidity, and pulse rate, enabling users to assess the risk level.Further testing involved monitoring extreme temperature conditions above 42°C, which is typically classified as a critical threshold for sunstroke. In these cases, the system triggered both the cloud alert and the relay module, activating emergency devices such as fans or alarms. This functionality proved particularly useful in outdoor environments, such as construction sites or sports activities, where the risk of heatstroke is more prevalent. The relay module was tested by simulating extreme conditions in a controlled environment, and it successfully activated the cooling system in response to the critical temperature and pulse rate values.

C.Reliability and Robustness

The reliability of the IoT-based sunstroke detection system was assessed over an extended period, simulating different environmental conditions. The system demonstrated high reliability in terms of both data collection and real-time monitoring. The NodeMCU ESP8266 microcontroller, which acts as the core of the system, exhibited stable performance throughout the tests, transmitting data to the Blynk Cloud without significant delays or connectivity issues. The Wi-Fi connectivity of the NodeMCU proved to be a major advantage, as it allowed for remote monitoring and alerts, ensuring that individuals at risk could be assisted promptly, even if they were in isolated locations. The integration of the Blynk Cloud platform played a significant role in ensuring that the system remained responsive and reliable. The cloud-based interface enabled easy access to the collected data and allowed real-time monitoring through the mobile application. The application provided an intuitive interface that displayed the environmental and physiological data, along with a color-coded status indicating the risk level. The ability to access the data from anywhere provided an additional layer of security, especially in scenarios where immediate action was needed to prevent heat-related illnesses. However, some limitations were observed during testing in areas with weak Wi-Fi signals or network congestion. In such cases, there were occasional delays in sending alerts or updating data on the Blynk platform. This issue was mitigated by optimizing the system to buffer data locally until a stable connection was available. While the system's performance was satisfactory in most real-world conditions, improvements in network resilience could further enhance its robustness in low- coverage areas.

CONCLUSION

This research work presented the design and simulation of an IoT-based sunstroke detection system aimed at enhancing personal healthcare and safety. The system integrates NodeMCU, DHT11, DS18B20, and a pulse sensor to monitor critical parameters such as internal and external temperatures and pulse rate. By leveraging Blynk Cloud and IoT technology, real-time alerts and data visualization were enabled, allowing timely medical intervention in case of abnormalities. The simulation, carried out using Proteus Design Suite, successfully validated the system's ability to detect early signs of sunstroke. This research article demonstrates the potential of IoT in preventive healthcare, offering a cost-effective, portable, and reliable solution that can be further enhanced and implemented in real-life scenarios. In future, the system can be extended by integrating GPS tracking, emergency contact notifications, and AI-based data analysis to predict health risks more accurately. Additional biomedical sensors can also be included to monitor hydration levels, blood pressure, and body movement. With advancements in wearable technology, this IoT-based system holds promise for real-time health monitoring in outdoor environments, especially for vulnerable populations such as children, athletes, and the elderly.

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