Non-Invasive Blood Glucose and Stress Monitoring System Using IOT

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***Abstract*—The rise in diabetes and stress-related disorders has created a greater need for non-invasive, real-time health monitoring systems. Traditional methods for measuring blood glucose can be painful and inconvenient, making them unsuitable for continuous monitoring. Often, stress is measured using subjective questionnaires that lack precision. To address these problems, this work introduces a non-invasive blood glucose and stress monitoring system that uses the Internet of Things (IoT). It aims to provide continuous, portable, and affordable health tracking. The system uses three sensors: the Grove Galvanic Skin Response (GSR) sensor for skin conductance, the DS18B20 digital thermometer for skin temperature, and the MAX30100 pulse oximeter for pulse rate and SpO_2. These sensors connect to the ESP8266 NodeMCU microcontroller. The microcontroller serves as the main unit for data collection, analysis, and wireless communication. The physiological signals gathered help determine stress levels and estimate blood glucose trends without invasive methods. Data is transmitted through Wi-Fi, and real-time readings are securely stored in Firebase Realtime Database for cloud access. A web interface hosted on GitHub enables remote monitoring on multiple devices. Meanwhile, local data visualization is available through an I²C LCD display and Arduino serial monitor for debugging. The system performs reliably. It shows consistent data between local and cloud setups, ensuring trustworthiness for real-time use. This prototype offers a scalable, portable, and cost-effective health monitoring solution. It has potential for early diagnosis and long-term management of chronic conditions. Future improvements will focus on better calibration methods and integrating machine learning to increase accuracy.**

***Index terms*—IoT, Blood Glucose, Sensors, ESP8266, Stress**

I. INTRODUCTION

A major worldwide health concern is the rising incidence of non-communicable diseases like diabetes and stress-related illnesses. The invasive procedures used in traditional blood glucose monitoring methods, such as finger-prick testing, are uncomfortable and frequently deter frequent use. Likewise, stress is still poorly understood even though it plays a significant role in mental and physical health problems. These difficulties underscore the necessity for accessible, user-friendly, non-invasive, real-time health monitoring systems. With the development of embedded technologies and the Internet of Things (IoT), effective and portable health monitoring solutions are now possible. This project uses the Internet of Things to propose a non-invasive blood glucose and stress monitoring system.

Using an ESP8266 microcontroller, the system uses three sensors: the Grove GSR sensor measures skin conductivity (a sign of stress), the DS18B20 temperature sensor measures body temperature, and the MAX30100 pulse oximeter records photoplethysmography (PPG) signals. Together, these sensors offer information about physiological parameters associated with stress levels and glucose fluctuations. Wi-Fi wirelessly transfers sensor data to the Firebase Realtime Database, enabling secure cloud storage and remote access. For local real-time data visualization and debugging, a serial monitor is also utilized. The goal of this system is to provide a non-invasive, portable, and affordable option for ongoing health monitoring. It is a prototype for wearable medical technology that may be extremely important in the future.

II. LITERATURE SURVEY

A study can used the MAX30100 sensor with a NodeMCU microcontroller for non-invasive blood glucose monitoring. The sensor captures pulse oximetry and heart rate signals. The NodeMCU processes these signals and sends them through IoT connectivity to the Blynk mobile app. This setup allows for real-time patient monitoring. Caregivers and doctors can access important health data remotely. By combining affordable IoT hardware with cloud-based dashboards, the system improves data access and decision-making. This solution supports ongoing patient care, reduces hospital visits, and helps detect abnormal glucose levels early[1].

A new portable and low-cost insulin monitoring device was proposed. It features an LED panel and a sensing unit that uses optical radiation to measure glucose changes without invasive methods. The collected signals were assessed using error grid analysis to ensure its accuracy and clinical reliability in managing diabetes. The system provides real-time glucose readings without the need for finger-pricking. Its compact design and low price make it ideal for home monitoring and remote healthcare. By delivering continuous and accessible data, the device aids in effective diabetes treatment and lifestyle management.[2].

A simple system was created to monitor blood glucose levels without using invasive methods. It relies on infrared (IR) transmitters and receivers connected to a NodeMCU microcontroller. The device uses a Wi-Fi connection to send patient data to online platforms for easy access. Along with glucose readings, it includes information such as BMI, height, and weight to improve the accuracy and dependability of the assessment. The system offers a quick and efficient evaluation, decreasing the need for invasive procedures. This method allows for accessible, continuous, and accurate health monitoring for managing diabetes[3].

The proposed system is a lightweight, non-invasive glucose monitoring device. It aims to address the discomfort and limitations of traditional invasive methods. The device uses photodetector technology along with near-infrared (NIR) LEDs to penetrate the skin and estimate glucose levels based on how light is absorbed. The collected signals are processed and sent via Wi-Fi, allowing for easy connectivity and remote monitoring. While the device shows promise for NIR-based glucose detection, its accuracy can be influenced by skin color, thickness, and pigmentation. These differences affect how light is absorbed and scattered, resulting in inconsistent readings. Therefore, calibration techniques and adaptive algorithms are needed to improve accuracy and reliability for a wider range of users[4].

The proposed model uses a non-invasive blood glucose monitoring system that combines a photodiode with visible red laser light to detect glucose. The collected data is sent to a cloud network through ThingSpeak. The Blynk application offers an easy-to-use interface for remote viewing and monitoring. Testing showed that the monitor has a glucose measurement error of less than 20%. This suggests it may serve as a dependable alternative to traditional invasive methods, but more work is needed to increase accuracy[5].

A project investigated how glucose molecules absorb light at different wavelengths. By looking at how they responded to multiple wavelengths, the study aimed to find the best range for non-invasive glucose detection. The results showed that light absorption could help estimate blood glucose levels without needing a sample. This wavelength analysis lays the groundwork for future non-invasive glucose monitoring systems. The research offers both a theoretical and practical basis for creating accurate, portable devices for diabetes care[6].

The study used near-infrared (NIR) spectroscopy-based laser technology to show that it is possible to track and measure blood glucose levels without invasive methods. This technique leverages the interaction of infrared light with biological tissues. It allows for estimating glucose concentration based on how light is absorbed and scattered. The results confirmed that NIR spectroscopy could be a promising option for continuous and painless glucose monitoring[7].

A non-invasive glucose monitoring device was created using Near-Infrared (NIR) spectroscopy along with the iGLU framework, Deep Neural Networks (DNN), and an open IoT platform. The system processed spectral data with machine learning algorithms to estimate blood glucose levels and allowed for easy connectivity for remote monitoring. Experimental results showed that the glucose levels measured by the device closely matched actual reference values. This demonstrates its effectiveness and potential for real-world healthcare use.[8].

III. METHODOLOGY

The DS18B20 sensor measures skin temperature, the GSR sensor detects skin conductance to measure stress, and the MAX30100 sensor measures blood oxygen levels and pulse rate. The ESP8266 microcontroller, the central processing unit, is connected to these sensors. After gathering and processing the raw signals, the ESP8266 transmits the information via Wi-Fi. The processed values are displayed on an I2C-based LCD panel for local monitoring, providing the user with real-time feedback. The data is also uploaded to Firebase cloud storage by the ESP8266, enabling remote access and display on mobile platforms or web dashboards. For longer-term healthcare applications, this configuration ensures remote accessibility, real-time feedback, and ongoing
monitoring.

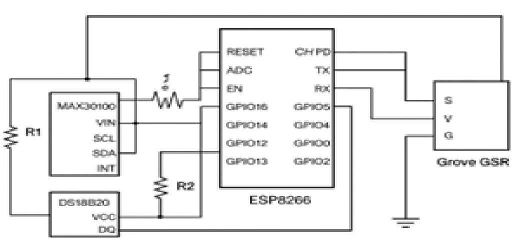


Fig.1: Circuit Diagram

IV. SPECIFICATION

ESP8266 Node MCU: Espressif Systems developed the ESP8266, a low-cost Wi-Fi microcontroller module. It features an integrated TCP/IP protocol stack, a 32-bit Tensilica L106 processor, and enough GPIO pins to interface to various peripherals and sensors. The ESP8266 is frequently used in Internet of Things applications for wireless data transfer due to its tiny size, low power consumption, and affordability. It acts as the primary controller for this project, reading, processing, and uploading sensor data to Firebase for online visualization.

Fig.2: ESP8266

MAX30100: The MAX30100 (Oximeter) is a low-power sensor that measures pulse rate and blood oxygen levels (SpO_2) using red and infrared light. It combines LEDs, a photodetector, and signal processing in one module and communicates through I^2C. It is compact and works well for wearable health monitoring devices.

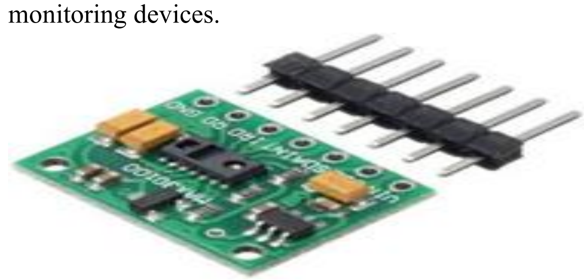


Fig.3: MAX30100

Grove GSR Sensor**:** The Grove GSR (Galvanic Skin Response) sensor measures skin conductance. This changes with sweat gland activity. The sensor helps detect stress or emotional arousal by monitoring changes in the skin's electrical resistance. It provides an analog signal, making it easy to connect with microcontrollers.

Fig.4: Grove GSR Sensor

DS18B20 : The digital temperature sensor DS18B20 has an accuracy of ±0.5°C. It uses the One-Wire protocol for communication. The temperature range that this sensor can detect is -55°C to +125°C. It is ideal for embedded and Internet of Things applications since it can accommodate several sensors on a single data line.

Fig. 5 : DS18B20

I2C LCD: An I2C LCD is a character display module that uses the I²C (Inter-Integrated Circuit) protocol. This reduces wiring from 16 pins to only two data lines, SDA and SCL. It is often used in microcontroller projects to display sensor readings, messages, or system status. The module supports adjustable contrast and has a built-in backlight for improved visibility.

Fig.6: I2C LCD

BREAD BOARD: Without soldering, electronic circuits can be constructed and tested using a breadboard, a reusable prototyping platform. Under a plastic surface, it has interconnected rows and columns of conductive metal strips that make it simple to insert and rearrange components and jumper wires.

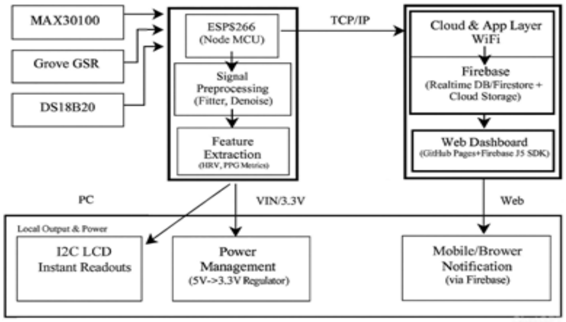
Fig.7: Bread Board

JUMPER WIRE: A jumper wire can be either male or female and is a short, solid-tipped, insulated wire. It is employed to establish fast, transient connections between breadboard components or between a breadboard and other devices. In order to test, prototype, and modify circuits without soldering, jumper wires are necessary.

Fig. 8: Jumper Wire

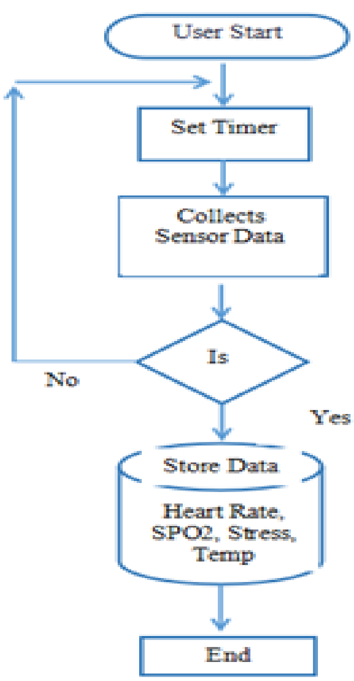
V. BLOCK DIAGRAM

The DS18B20 sensor measures skin temperature, the GSR sensor detects skin conductance to measure stress, and the MAX30100 sensor measures blood oxygen levels and pulse rate. The ESP8266 microcontroller, the central processing unit, is connected to these sensors. After gathering and processing the raw signals, the ESP8266 transmits the information via Wi-Fi. The processed values are displayed on an I2C-based LCD panel for local monitoring, providing the user with real-time feedback. The data is also uploaded to Firebase cloud storage by the ESP8266, enabling remote access and display on mobile platforms or web dashboards. For longer-term healthcare applications, this configuration ensures remote accessibility, real-time feedback, and ongoing monitoring.



VI. DATA FLOW DIAGRAM

The data flow of the proposed system begins with sensor acquisition. The MAX30100 captures pulse rate and SpO_2 levels. The DS18B20 measures skin temperature. The GSR sensor records skin conductance. The ESP8266 NodeMCU collects and processes these readings, serving as the central controller. The processed data goes to two outputs at the same time: locally, the values show up on the I²C LCD for real-time monitoring. Remotely, the data is sent via Wi-Fi and stored securely in Firebase. From Firebase, users can retrieve the readings and view them on a web interface hosted on GitHub. This structured data flow ensures effective acquisition, real-time visualization, cloud storage, and reliable remote access.



VI. SYSTEM IMPLEMENTATION

Hardware Implementation: The hardware design focuses on the ESP8266 NodeMCU. This unit acts as the main controller and communication device. We integrated three biomedical sensors to measure physiological parameters. The MAX30100 pulse oximeter measures pulse rate and SpO_2. The DS18B20 digital thermometer checks skin temperature. The Grove GSR sensor measures skin conductance. We used an I²C-based LCD module to show readings locally, allowing for immediate monitoring. The ESP8266 also connected to Wi-Fi to send processed data to the cloud. Proper wiring and pin mapping provided stable power distribution and smooth communication among the components.

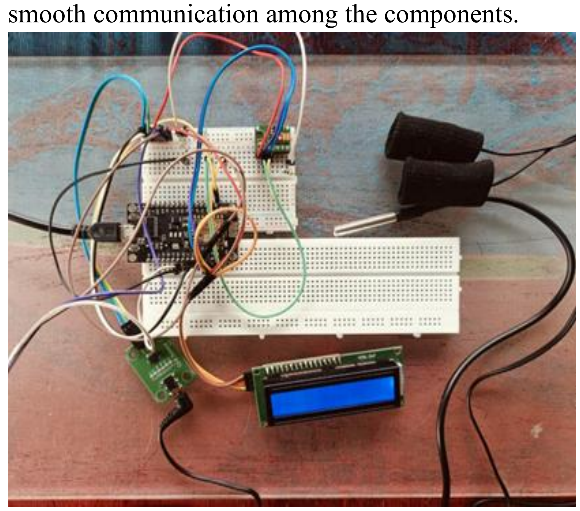


Fig.9: Hardware Components Setup

Software Implementation: The ESP8266 NodeMCU was programmed and debugged using the Arduino IDE, which was used to create the software. To facilitate seamless data acquisition and display, sensor-specific libraries for the MAX30100, Grove GSR, DS18B20, and I²C LCD were integrated. To send real-time data from the ESP8266 to the cloud, a Firebase library was put into place. Additionally, a web interface hosted on GitHub was developed to remotely visualize the uploaded data, offering a straightforward and user-friendly monitoring platform. Sensor initialization, ongoing data collection, local display updates, and Wi-Fi cloud uploads were all managed by the firmware. In order to ensure consistent connectivity and dependable operation throughout the process, error handling mechanisms were added.

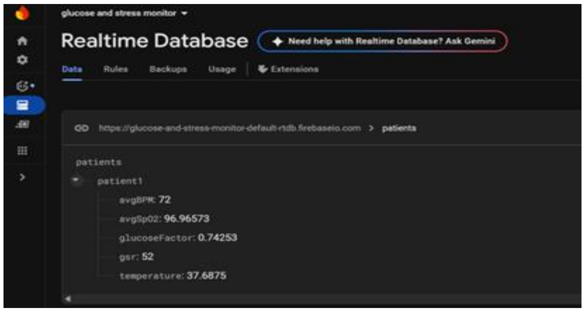
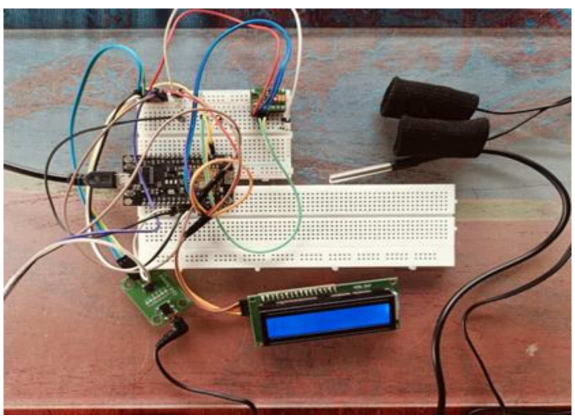


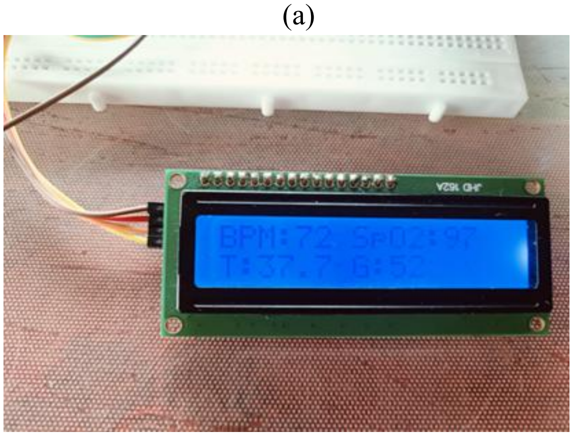
Fig.10: Firebase

VII. RESULT

The ESP8266 NodeMCU collected data from the GSR sensor (skin conductance), DS18B20 (temperature), and MAX30100 (pulse rate & SpO_2). An I²C LCD displayed readings locally, while data was sent via Wi-Fi to Firebase for secure storage. A GitHub-hosted web interface enabled remote monitoring across devices. The system delivered real-time updates with no noticeable latency, ensuring reliable and consistent performance.



(a)



(b)

Fig. 11(a&b) : Result Displayed on LCD

The images from the I²C LCD module display physiological parameters in real time. These include pulse rate and SpO_2 from the MAX30100, skin temperature from the DS18B20, and skin conductance from the Grove GSR sensor. These outputs show that the sensors work well with the ESP8266 microcontroller and confirm reliable data collection. The clear readings emphasize the system's portability and ease of use. This allows for immediate health monitoring on the device and access to cloud-based data.

Fig. 12 : Result Web Page

VIII. CONCLUSION

The proposed non-invasive blood glucose and stress monitoring system successfully combines several low-cost sensors with an IoT platform to provide real-time physiological data. While the prototype faces challenges related to sensor accuracy, calibration needs, and hardware limitations, it shows that non-invasive methods can work for continuous health monitoring. This system could serve as a low-cost, portable, and easy-to-use option for initial glucose and stress trend analysis. With improvements in hardware, signal processing, cloud integration, and clinical validation, this project could develop into a dependable wearable healthcare device that supports preventive care and remote patient monitoring.

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