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Towards Intelligent Diabetes Care: A Smart Embedded Technology Approach for Real-Time Monitoring and Management

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Abstract

The increasing prevalence of diabetes mellitus has intensified the demand for intelligent, real-time monitoring solutions that can support timely intervention and improve disease management, particularly in resource-constrained settings. This study presents a smart embedded technology–based diabetes management system designed to enable continuous glucose monitoring, real-time data transmission, and automated alert generation. The proposed system integrates a glucose sensor with an ESP32 microcontroller to acquire physiological data, which are processed and transmitted via an Internet of Things (IoT) framework to a cloud-based platform for visualization, storage, and analysis. A user-friendly dashboard developed using the Blynk IoT platform provides real-time access to glucose readings and historical trends for both patients and healthcare providers, while automated notifications are triggered when glucose levels exceed predefined clinical thresholds. A prototype-driven methodology was adopted to support iterative design, system refinement, and functional validation. Experimental evaluation of the developed prototype demonstrated high responsiveness, reliable cloud synchronization, and effective alert delivery, confirming the feasibility and robustness of the proposed approach. The system offers a low-cost, scalable, and accessible solution for intelligent diabetes care, with potential applications in hospitals, home-based monitoring, telemedicine platforms, and underserved communities. The findings of this study highlight the viability of embedded and IoT technologies in advancing real-time, connected healthcare systems and provide a foundation for future enhancements incorporating predictive analytics and intelligent decision-support mechanisms.

Keywords: Smart Diabetes Management, Embedded Systems, Internet of Things (IoT), Real-Time Health Monitoring

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1 Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels, resulting either from insufficient insulin production or the body's inability to effectively utilize insulin. According to the International Diabetes Federation (IDF, 2021), over 537 million adults worldwide were living with diabetes in 2021, a figure projected to rise to 643 million by 2030 if current trends persist. Poorly managed diabetes can lead to severe complications, including cardiovascular disease, kidney failure, and vision impairment, highlighting the critical need for continuous monitoring and timely intervention. Traditional diabetes management methods, such as periodic glucose testing with standalone glucometers, manual record-keeping, and periodic physician consultations, remain prevalent but are susceptible to human error, data loss, and delayed responses (Armenta et al., 2020).The advent of smart technologies and affordable embedded systems offers transformative opportunities for chronic disease management. Embedded systems, incorporating microcontrollers, sensors, and communication modules, enable automated, real-time health monitoring, bridging the gap between patients and healthcare providers. The ESP32 microcontroller, a low-cost and energy-efficient platform with integrated Wi-Fi and Bluetooth, is particularly well-suited for Internet of Things (IoT)–based healthcare applications. When coupled with glucose sensors and cloud-based platforms such as Blynk IoT, the ESP32 can acquire, process, and transmit glucose readings in real time, providing actionable data to patients and clinicians for informed decision-making (Kassal et al., 2018). The platform supports interactive mobile dashboards, real-time alerts, and historical trend visualization, facilitating proactive disease management, especially in low-resource or rural settings where access to specialized care is limited.

Recent studies have demonstrated the potential of IoT and embedded solutions in improving diabetes care. Armenta et al. (2020) highlighted how sensor-enabled platforms can reduce clinical workload while enhancing patient adherence to monitoring schedules. Kassal et al. (2018) emphasized the effectiveness of real-time remote monitoring in preventing complications and optimizing treatment outcomes. Despite these advances, gaps remain in developing integrated, cost-effective, and scalable embedded frameworks that combine continuous monitoring, real-time alerts, predictive analytics, and secure data management. Most existing systems focus on either commercial-scale monitoring solutions or theoretical models, leaving a critical need for practical, low-cost implementations tailored to individual patients and resource-constrained environments.To address these limitations, this study proposes the design and implementation of a smart diabetes management system leveraging the ESP32 microcontroller and Blynk IoT platform. The system aims to automate glucose data collection, provide real-time visualization and alerts, and enhance patient self-management while supporting clinician oversight. Key features include sensor-based glucose acquisition, real-time mobile dashboards, predictive notifications for abnormal readings, and historical trend analysis. The solution emphasizes usability, scalability, and data security, offering a framework adaptable for future expansion to include additional physiological metrics.By integrating embedded technology with IoT and mobile applications, this study seeks to move beyond conventional monitoring approaches, providing an intelligent, data-driven platform that empowers patients, reduces risks of complications, and enables timely clinical interventions. This work contributes to the growing field of smart healthcare solutions by demonstrating a practical, low-cost, and scalable approach for real-time diabetes monitoring and management.

1.1 Related Works

Recent advancements in embedded systems, Internet of Things (IoT), and intelligent data analytics have significantly transformed diabetes management, enabling real-time monitoring, personalized care, and remote clinical interventions. Khalifa et al (2023) developed a smart IoT-based diabetes management system that integrates embedded glucose sensors, physical activity trackers, and wireless communication modules to provide continuous glucose and lifestyle monitoring. Their system enhanced patient engagement and facilitated personalized healthcare delivery; however, challenges related to power efficiency, data accuracy during transmission, and data security were identified. These limitations underscore the need for optimized embedded architectures and robust security mechanisms in real-world deployments.Addressing data security concerns, Ettaloui et al (2024) proposed an IoT–blockchain–based framework to ensure data integrity and privacy in diabetes monitoring systems. By leveraging blockchain immutability, their model improved transparency and secure data sharing, which is particularly relevant in regions with evolving data protection regulations. Nevertheless, scalability and latency issues associated with blockchain networks remain significant challenges, despite mitigation attempts using lightweight protocols. Similarly, Tlemçani et al. (2025) employed blockchain-based edge computing to enhance scalability, reduce latency, and strengthen cybersecurity in healthcare IoT systems, though computational overhead and synchronization complexities persisted.

Machine learning–driven solutions have also gained prominence in diabetes care. Kulshrestha et al. (2024) introduced a machine learningenabled IoT framework for early diabetes detection, employing supervised learning models to analyze real-time physiological data. Their work demonstrated improved scalability and suitability for resource-constrained environments; however, maintaining predictive accuracy across diverse population datasets remains a challenge. Advanced deep learning approaches were explored by Alkanhel et al. (2024), who proposed a hybrid CNN–GRU model for real-time glucose forecasting using embedded IoT architectures. While the model achieved high prediction accuracy and adaptability, its computational demands highlighted the trade-offs between intelligence and edge-device efficiency.Several studies have emphasized usability, visualization, and patient-centered design. Saha et al. (2024) focused on integrating IoT with advanced data visualization techniques to transform complex glucose data into actionable insights for patients and clinicians. Although their system improved treatment adherence and decision-making, maintaining system responsiveness under high data loads remained a concern. Likewise, Andreou et al. (2025) emphasized IoT interoperability for managing diabetes alongside comorbid conditions, demonstrating improved quality of life through unified monitoring platforms, albeit with challenges related to cross-device communication and data standardization.

Non-invasive and alternative sensing technologies represent another emerging research direction. Refaie and Abdelaziz (2024) proposed a PPG-based non-invasive glucose monitoring system integrated with AI and IoT platforms, improving patient comfort and reducing infection risks. However, variability in signal calibration and physiological conditions affected prediction accuracy. Similarly, Wang et al. (2025) and Ermis et al. (2025) explored nanowire breath sensors and microneedle-based glucose sensing technologies, respectively, offering promising minimally invasive solutions but facing challenges related to sensor stability, calibration, and cost-effectiveness.Integrated insulin delivery systems have also been investigated. Rashid et al. (2023) developed an IoT-based smart insulin delivery system combining glucose sensors with automated insulin pumps, improving glycemic control and affordability. Earlier works such as Lain (2021) and Aldawood et al. (2021) demonstrated the potential of embedded bolus estimation and microneedle-based insulin

delivery systems, though real-time responsiveness, biocompatibility, and long-term reliability remained open challenges.Broader system-level approaches include cloud-based and smart-city deployments. Singh et al. (2025) proposed a cloud-based embedded system for scalable diabetes monitoring, while Mirshekali et al. (2025) integrated embedded health systems into smart city infrastructures. Although these approaches enhance scalability and predictive intelligence, they rely heavily on stable network connectivity and raise significant data privacy concerns. Context-specific applications, such as vehicular health monitoring for diabetic drivers (Hossain et al., 2023) and pediatric diabetes management using humanoid robots (Al-Taee et al., 2025), further demonstrate the expanding scope of embedded diabetes management solutions, albeit with increased system complexity and cost.

Despite these substantial advancements, notable research gaps persist. Many existing systems are designed for high-resource environments, limiting affordability and accessibility in developing regions such as Nigeria. Interoperability, scalability, energy efficiency, and secure data handling remain unresolved challenges across multiple studies (Ettaloui et al., 2024; Tlemçani et al., 2023). Moreover, most solutions focus on isolated functionalitiessuch as monitoring, prediction, or insulin deliveryrather than offering an integrated, end-to-end diabetes management framework adaptable to resource-constrained settings.Consequently, this study is motivated by the need for a cost-effective, scalable, and secure smart diabetes management system using embedded technology, specifically tailored for environments with limited infrastructure. By integrating real-time monitoring, efficient local processing, secure communication, and user-friendly interfaces, the proposed system seeks to bridge the gap between advanced research prototypes and deployable solutions for diverse healthcare contexts.

2.0 Materials and Methods

This study adopts a prototype-based system development methodology to design and implement a smart embedded diabetes management system capable of real-time physiological monitoring, data transmission, and user interaction. The methodology is selected to support iterative system refinement, early functional validation, and technical risk mitigation, which are essential for embedded healthcare applications where reliability, latency, and usability are critical. The methodological process begins with system requirement definition, informed by limitations observed in conventional diabetes management solutions, including manual data logging, lack of continuous monitoring, and delayed clinical feedback. These requirements guided the development of a functional prototype that integrates sensing, embedded processing, communication, and visualization components within a unified Internet of Things (IoT) framework.

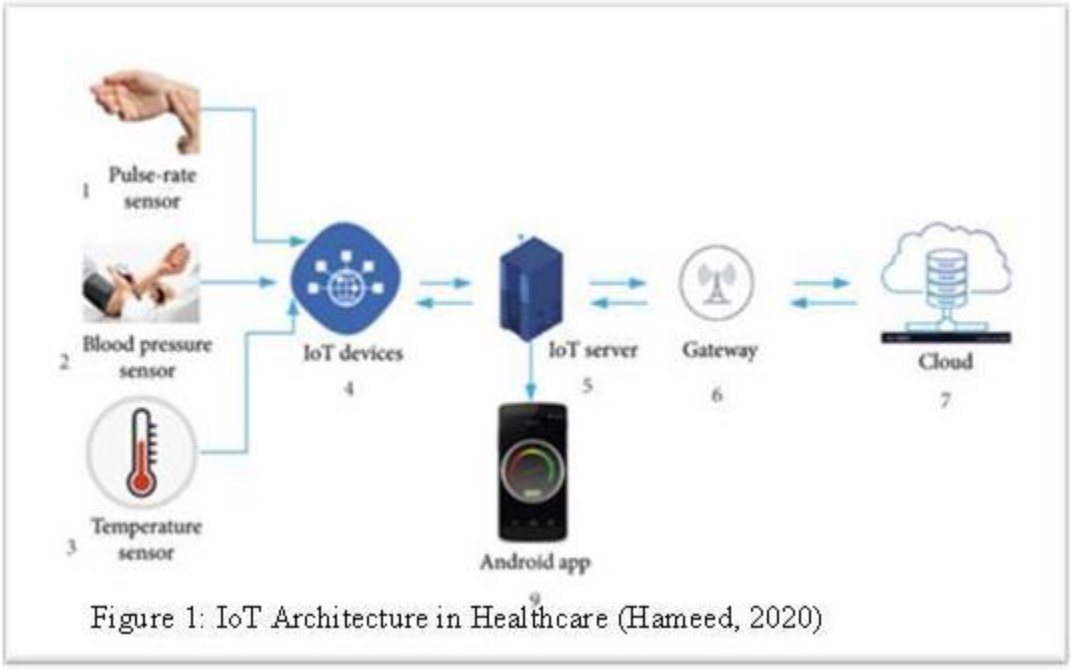


Figure 1: IoT Architecture in Healthcare (Hameed, 2020)

The overall system architecture developed under this methodology is presented in Figure 1, which illustrates the end-to-end data flow and functional blocks of the proposed system. Physiological parameters, including pulse rate, blood pressure, and body temperature, are acquired through embedded sensors forming the perception layer. These sensor outputs are interfaced with an IoT device unit, which serves as the central data aggregation and preprocessing node. At this stage, raw sensor data are conditioned, digitized, and validated to ensure accuracy prior to transmission. Processed data are transmitted from the IoT device to an IoT server, which manages device connectivity, data synchronization, and service requests. Communication between system components is achieved through wireless networking, with a gateway module facilitating secure and reliable data exchange between the IoT server and cloud infrastructure. The cloud layer provides centralized data storage, enabling persistence of historical records and supporting future analytical extensions.

A mobile application interface retrieves processed data from the IoT server and presents real-time physiological information to users in a structured format. This application layer supports continuous health status visualization and enhances situational awareness without requiring direct interaction with embedded hardware. The separation of sensing, processing, communication, and presentation functions, as depicted in Figure 1, ensures modularity, scalability, and simplified system maintenance. The prototype methodology enables incremental integration and evaluation of hardware and software components. Each development iteration focuses on validating specific technical parameters, including sensor accuracy, data transmission latency, processing stability, and interface responsiveness. Identified limitationssuch as timing delays, data handling inefficiencies, or communication inconsistenciesare addressed before progressing to subsequent development stages.System testing is conducted under simulated operational conditions to assess functional correctness and performance consistency. This iterative validation approach allows early detection of technical faults and reduces deployment risks. Additionally, the modular design permits future system expansion, including integration of additional physiological sensors or advanced analytics modules.

2.1 The Proposed System

The system is a smart embedded diabetes management platform designed to overcome the limitations of conventional glucose monitoring approaches by enabling continuous data acquisition, real-time transmission, automated alerting, and remote accessibility. The system integrates embedded hardware, wireless communication, and cloud-based services to support proactive diabetes monitoring and timely clinical awareness.At the core is an ESP32 microcontroller, selected for its low power consumption, integrated Wi-Fi capability, and suitability for Internet of Things (IoT) health applications. The ESP32 serves as the central processing and coordination unit, interfacing with physiological sensors, performing preliminary data handling, and managing data transmission to external platforms.It operates through a layered architecture to ensure modularity, scalability, and reliability. At the sensing layer, physiological data are collected using a glucose sensor (such as a glucometer or continuous glucose monitoring module) and a temperature sensor. An accelerometer may be incorporated to capture patient activity levels, supporting contextual interpretation of glucose variations. These sensors enable continuous and automated data capture, eliminating the need for manual logging.The processing layer is implemented on the ESP32 microcontroller, where sensor data are aggregated, formatted, and preprocessed prior to transmission. This stage ensures that readings are validated and appropriately structured for cloud communication. The embedded processing capability reduces transmission overhead and enhances system responsiveness.

The communication layer enables real-time data transmission from the ESP32 to cloud services using Wi-Fi or cellular connectivity (e.g., 4G where applicable). This layer ensures reliable data delivery to remote servers and supports continuous system operation. The processed health data are transmitted to the Blynk Cloud platform, which acts as the central data repository and interaction hub.

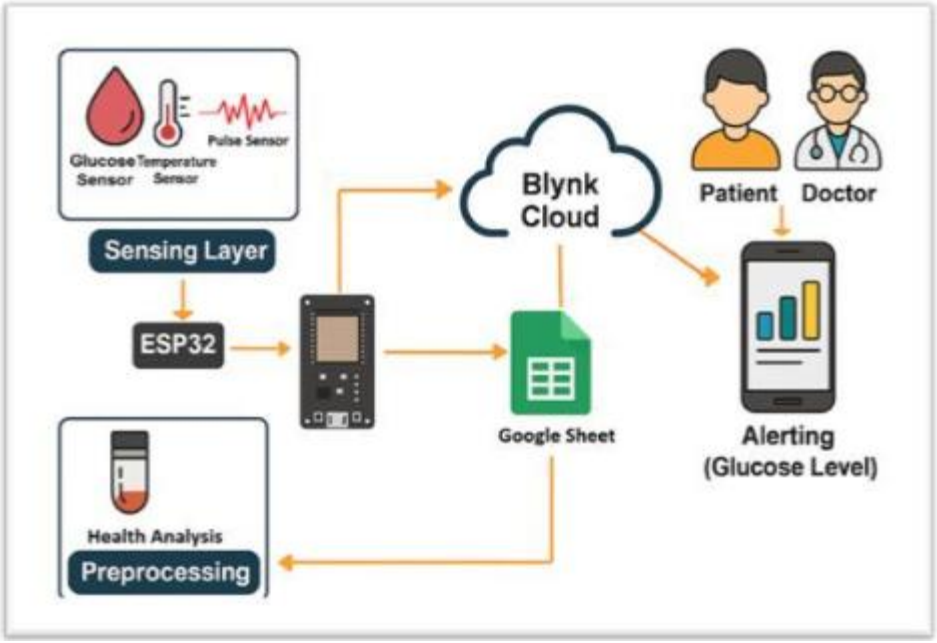


Figure 2: High-Level Model of the Proposed System

At the application layer, data stored in the cloud are visualized through a user-friendly mobile application interface. The application provides real-time display of glucose levels, historical trend graphs, and system notifications. Integration with external data storage platforms, such

as Google Sheets, enables long-term record keeping and facilitates data review by healthcare professionals. Automated alert mechanisms are implemented to notify patients and clinicians via mobile notifications or SMS when glucose readings exceed predefined thresholds.The proposed system supports bidirectional access, allowing both patients and healthcare providers to monitor glucose trends remotely and respond promptly to abnormal conditions. By combining continuous monitoring, cloud integration, and automated alerts, the system promotes proactive diabetes management and reduces reliance on periodic clinical visits.

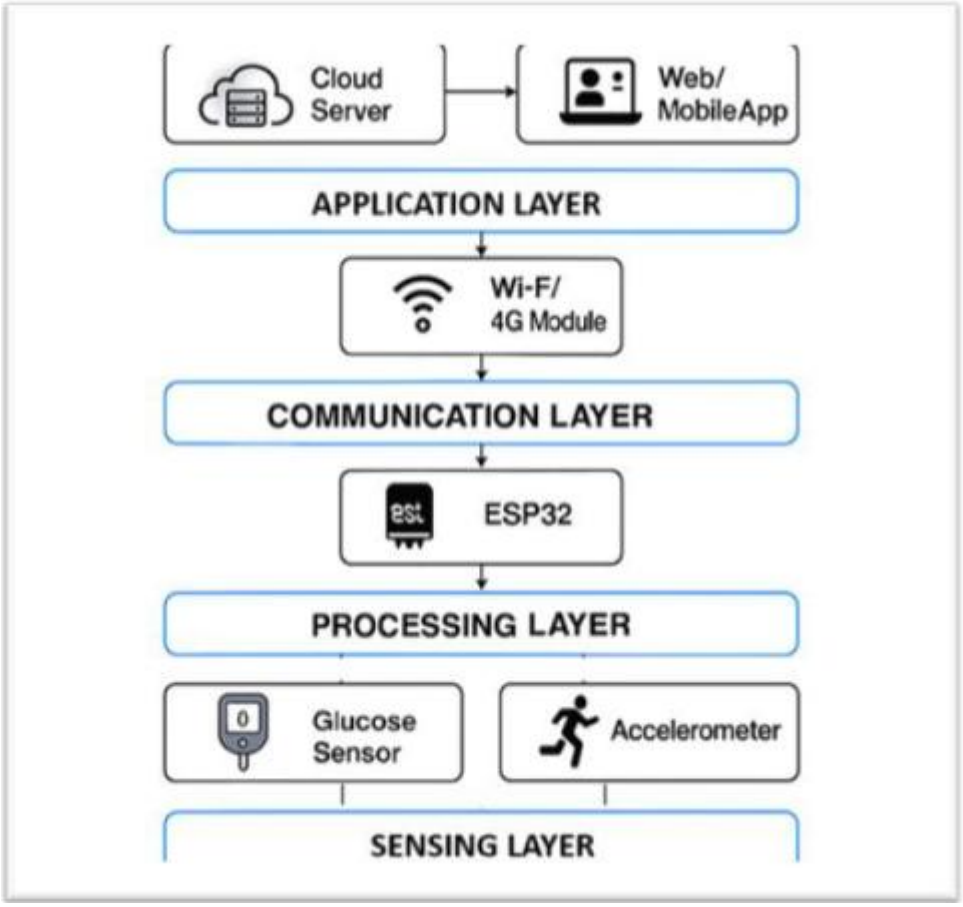


Figure 3: The System Architecture

2.2 Algorithmic Design and Mathematical Model

The operational logic of the proposed smart diabetes management system is governed by a structured real-time monitoring algorithm designed to ensure continuous data acquisition, timely analysis, and responsive alert generation. Upon system initialization, the embedded controller activates all sensing modules, including the glucose, pulse, and temperature sensors, and establishes communication with the ESP32 microcontroller. Once initialized, the system enters a continuous monitoring state in which physiological data are periodically sampled and forwarded to the microcontroller for preprocessing as expressed in the algorithm.

i. *Start the system.*
ii. *Initialize sensors (Glucose, Pulse, Temperature) and the ESP32 microcontroller.*
iii. *Continuously monitor and read sensor data (glucose levels, pulse rate, temperature).*
iv. *Transmit sensor data to the ESP32 for preprocessing.*
v. *Preprocess data (e.g., filter noise, calculate average if needed).*
vi. *Check if glucose level exceeds predefined critical threshold (either high or low).*

vii. *If critical level is detected:*
   a. *Send an alert message via Blynk Cloud.*
   b. *Notify both patient and doctor using mobile notifications.*
   c. *Log alert and data in Google Sheets for tracking and analysis.*

viii. *Else (if glucose is within normal range):*
   a. *Log sensor data in Google Sheets.*

ix. *Update user interface (Blynk Dashboard) with the latest glucose, pulse, and temperature readings.*

x. *Repeat steps 3–7 for continuous monitoring.*

xi. *Stop the system when monitoring session is ended or by user command.*

To support analytical interpretation and predictive assessment, a simplified mathematical model is incorporated into the system design. Glucose trend estimation is expressed as:

$$G(t+1) = G(t) + \alpha \cdot \Delta G$$

where G*(t)* is the current glucose level, ΔG denotes the recent rate of change in glucose level, and $\alpha$is a scaling coefficient influenced by contextual factors such as physical activity and insulin intake. This formulation provides a lightweight predictive mechanism suitable for resource-constrained embedded platforms while enabling short-term trend assessment. Alert generation is formally defined by a threshold-based decision rule:

$$If\ G(t) < Glow\ or\ G(t) > Ghigh \Rightarrow Trigger\ Alert$$

where G_{low} and G_{high} correspond to clinically defined hypoglycemic and hyperglycemic thresholds, respectively. To further enhance data reliability, smoothing techniques such as moving averages and statistical outlier detection are applied to mitigate the impact of transient measurement anomalies.

Results and Discussion

This section presents the results obtained from the implementation of the proposed smart diabetes management system. In the context of this study, the results focus on the realization of the system prototype and the validation of its functional operation. The implementation outcomes are illustrated through the user interface, system flowchart, and embedded software execution.The user interface demonstrates real-time visualization of physiological data and alert notifications, while the system flowchart confirms the logical sequence of data acquisition, processing, and cloud transmission. Although the internal data structures are not presented in this paper, they support efficient data handling and system responsiveness. The coding implementation validates the successful integration of sensors, the ESP32 microcontroller, and cloud services, confirming that the system operates as designed.

3.1 Design

The system design defines the architectural structure and interaction mechanisms of the proposed smart diabetes management system, with a strong emphasis on real-time data acquisition, embedded processing, cloud-based communication, and user interaction. Physiological data, including glucose levels and complementary vital parameters, are continuously acquired through embedded sensing units and transmitted to the ESP32 microcontroller, which serves as the central processing and coordination component. At this stage, the acquired sensor data are preprocessed to remove noise, validate readings, and prepare the data for decision-making operations. Following preprocessing, the system

evaluates the glucose readings against predefined clinical threshold values to determine whether the measured levels fall within normal or critical ranges. This decision-making logic enables the automatic detection of hypoglycemic or hyperglycemic conditions. When abnormal readings are identified, alert signals are generated and transmitted to the cloud platform, triggering real-time notifications to both patients and healthcare providers through the user interface. Simultaneously, all processed dataregardless of alert statusare transmitted to the cloud for logging, visualization, and historical analysis.A modular and layered architectural approach was adopted to enhance scalability, maintainability, and fault tolerance, ensuring reliable continuous operation in real-world healthcare environments. The user interface was designed with simplicity and clarity as core principles, providing intuitive access to live glucose values, historical trends, and alert notifications for both patients and clinicians. Key design features include dashboard-based visualization, automated alert mechanisms, configurable user settings, and report generation to support clinical review and informed decision-making. The sequential flow of data acquisition, preprocessing, decision evaluation, and alert generation is illustrated in the system flowchart presented in Figure 4.

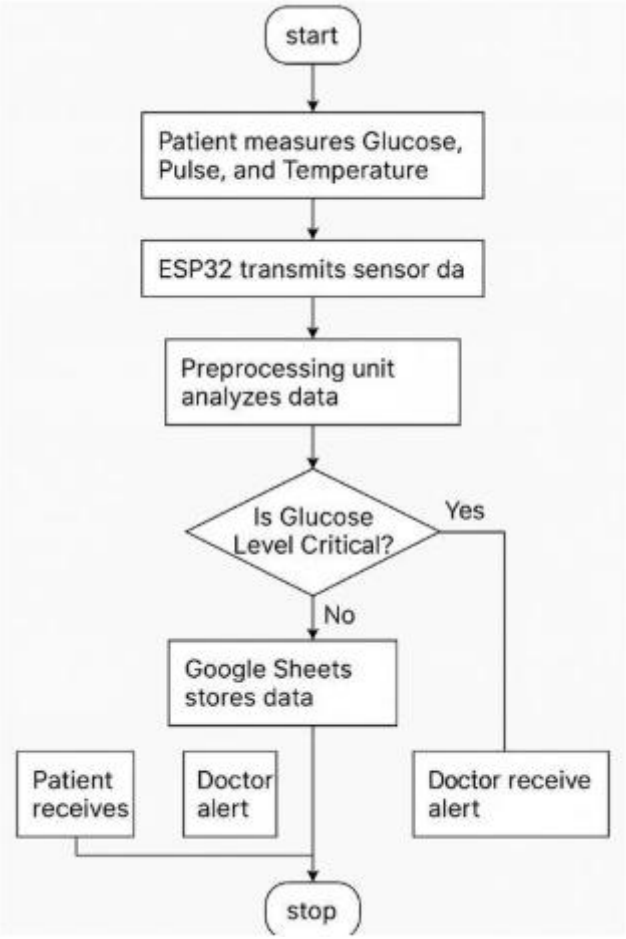


Figure 4: The System's Flowchart

3.2 Implementation

The system implementation involved the realization of both hardware and software components in accordance with the proposed design architecture. The ESP32 microcontroller served as the central processing and communication unit, interfaced with glucose, pulse, and

temperature sensors for real-time physiological data acquisition. The embedded firmware was developed using C/C++ within the Arduino IDE, leveraging ESP32-specific libraries for sensor integration and Wi-Fi connectivity. Real-time data visualization and alerting were implemented using the Blynk IoT platform, providing a responsive mobile interface for patients and clinicians. Sensor readings were logged to Google Sheets via Blynk webhooks, enabling lightweight cloud-based storage and historical data analysis without the need for complex database infrastructure. Basic security mechanisms, including encrypted communication and authentication tokens, were incorporated to protect data integrity and user access. The system was validated through functional testing under simulated conditions, confirming accurate data transmission, timely alerts, stable connectivity, and usability, thereby demonstrating the feasibility and effectiveness of the implemented prototype.The system dashboard designed using the Blynk IoT platform is presented in Figure 5, illustrating real-time visualization of glucose readings, alerts, and user interaction components.



Figure 5: System Dashboard Design

The evaluation of the developed prototype demonstrates the practical feasibility and effectiveness of embedded and IoT-driven technologies for real-time diabetes monitoring and management. Experimental testing revealed that physiological data acquired from the glucose and auxiliary sensors were reliably transmitted from the embedded device to the cloud-based dashboard with an average latency of less than two seconds. This level of responsiveness confirms the system's suitability for time-sensitive health monitoring applications, where delayed feedback could compromise patient safety.The alerting mechanism performed consistently across all test scenarios, with abnormal glucose readings successfully triggering instant notifications delivered to both patients and designated healthcare providers. This real-time alert functionality is critical for early detection of hypoglycemic and hyperglycemic events and supports timely intervention. Furthermore, system reliability was observed throughout the testing period, as the ESP32 microcontroller maintained stable Wi-Fi connectivity and continuous synchronization with the cloud platform without data loss or communication failures.User interaction tests further indicated a high level of usability and acceptance. Test users reported that the dashboard interface was intuitive, visually clear, and

easy to navigate, enabling quick interpretation of glucose trends and system alerts without requiring technical expertise. This usability outcome reinforces the importance of user-centered design in embedded healthcare systems, particularly for chronic disease management where long-term adoption is essential.

4 Conclusion

This study presented the design, development, and evaluation of a real-time smart diabetes management system based on embedded and Internet of Things (IoT) technologies. The primary objective was to address the growing need for continuous glucose monitoring, timely detection of abnormal glucose levels, and improved accessibility to diabetes care, particularly in environments with limited healthcare resources. By integrating a glucose sensor with an ESP32 microcontroller and deploying the Blynk IoT platform for real-time data visualization, the system successfully demonstrated how embedded technologies can be leveraged to support proactive and remote diabetes management.The implemented system enabled continuous acquisition of glucose data, real-time transmission to a cloud-based dashboard, and automated alert generation when readings exceeded predefined thresholds. These features collectively ensured timely awareness for both patients and healthcare providers, thereby reducing delays in intervention that often characterize conventional glucose monitoring approaches. Experimental evaluation confirmed that the prototype achieved reliable performance in terms of responsiveness, system stability, and usability, with sensor readings transmitted and displayed in near real time and alerts triggered consistently under critical conditions. The integration of Google Sheets as a cloud-based data logging mechanism further facilitated historical data storage and trend analysis without introducing significant infrastructural complexity.

Beyond technical performance, the system highlights the broader potential of IoT-based monitoring solutions in transforming diabetes care delivery. The findings support the recommendation that healthcare providers consider adopting such systems to enhance patient monitoring, improve clinical decision-making, and reduce the burden on overstretched healthcare facilities. The modular and scalable architecture of the proposed solution makes it suitable for deployment across diverse application contexts, including hospitals and clinics for continuous patient monitoring, home-based care environments that empower patients with self-management tools, telemedicine platforms that support remote consultations, and rural or underserved communities where access to diabetes specialists is limited.The study also underscores the importance of complementary factors for effective system adoption. Patient education on interpreting glucose trends and responding appropriately to alerts is critical to maximizing the benefits of real-time monitoring systems. Furthermore, partnerships with healthcare institutions, government agencies, and non-governmental organizations can play a vital role in facilitating large-scale deployment, particularly in resource-constrained settings. Continuous refinement of sensor accuracy, system reliability, and user experience will further enhance trust, usability, and long-term adoption.

While the prototype demonstrated promising results, several opportunities for future research remain. These include integrating artificial intelligence techniques for predictive analysis of glucose trends, extending the system to incorporate additional health parameters such as diet, insulin intake, and physical activity, and exploring wearable form factors to improve mobility and user comfort. Large-scale clinical trials are also recommended to validate long-term accuracy, scalability, and real-world effectiveness across diverse patient populations.In conclusion, this study demonstrates that low-cost, IoT-enabled embedded systems can provide practical, scalable, and effective solutions for diabetes management. The proposed

system contributes to the advancement of smart healthcare technologies by bridging the gap between traditional glucose monitoring methods and intelligent, connected health monitoring platforms. It lays a solid foundation for future innovations aimed at improving chronic disease management and enhancing healthcare delivery in both developed and emerging economies.

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APPENDIX

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#define BLYNK_TEMPLATE_ID "TMPL2NP5Krfye"
#define BLYNK_TEMPLATE_NAME "HEALTH System"
#define BLYNK_AUTH_TOKEN "H3s-bNarjGCuhqrYXwAS0xY4SgUDk-e0"
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <Wire.h>
#include <MPU6050.h>
MPU6050 mpu;
char auth[] = BLYNK_AUTH_TOKEN;
charssid[] = "Jaxi";
char pass[] = "1234567890k";
#define TOUCH_SENSOR_PIN 12  // Touch sensor on D6 (GPIO12)
#define BUZZER_PIN 13        // Buzzer on D7 (GPIO13)
void setup() {
  Serial.begin(115200);
  Wire.begin(5, 4);  // SDA, SCL for MPU6050
  Blynk.begin(auth, ssid, pass);
  pinMode(TOUCH_SENSOR_PIN, INPUT);  // Set the touch sensor pin as input
  pinMode(BUZZER_PIN, OUTPUT);       // Set buzzer pin as output
  digitalWrite(BUZZER_PIN, LOW);     // Ensure buzzer is off initially
  mpu.initialize();
  if (mpu.testConnection()) {
    Serial.println("MPU6050 connected");
  } else {
    Serial.println("MPU6050 connection failed");
  }
}
```

```
void loop() {
  Blynk.run();
  int16_t ax, ay, az;
  mpu.getAcceleration(&ax, &ay, &az);
  float angleX = atan2(ay, az) * 180 / PI;
  float angleY = atan2(ax, az) * 180 / PI;
  Serial.print("X angle: ");
  Serial.println(angleX);
  Serial.print("Y angle: ");
  Serial.println(angleY);
  // Send angles to Blynk for display
  Blynk.virtualWrite(V0, angleX);
  Blynk.virtualWrite(V1, angleY);
  boolfallDetected = false;
  boolpanicEmergency = false;
  // Check for fall detection
  if ((angleY>= 20 &&angleY<= 50) || (angleY>= 80 &&angleY<= 120)) {
    Blynk.virtualWrite(V4, "Fall detected");
    Serial.println("Fall detected");
    fallDetected = true;
  }
  // Check for panic emergency (touch sensor activated)
  if (digitalRead(TOUCH_SENSOR_PIN) == HIGH) {
    Blynk.virtualWrite(V4, "Panic Emergency");
    Serial.println("Panic Emergency");
    panicEmergency = true;
  }

  // Activate buzzer if either condition is met
```

```
  if (fallDetected || panicEmergency) {
    digitalWrite(BUZZER_PIN, HIGH);  // Turn on buzzer
  } else {
    digitalWrite(BUZZER_PIN, LOW);   // Turn off buzzer
  }

  delay(500);  // Delay for readability
}
```