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IoT based Glucose Monitoring and Alerting System Using NodeMCU Microcontroller

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Abstract: In hospitals and healthcare facilities, continuous monitoring of saline levels is crucial to ensure timely refilling and prevent any interruptions in patient treatment. Traditional saline monitoring requires manual intervention, which can lead to delays in refilling, posing a risk to patients. This paper presents an IoT-based saline monitoring system using the ESP8266 microcontroller, ultrasonic sensors, and Telegram bot integration to automate the process. The system measures the saline levels in two bottles, alerts healthcare staff via Telegram notifications, and activates a buzzer when the saline level is critically low. The proposed system enhances patient safety, minimizes manual supervision, and improves efficiency in hospital management.
Keywords: IoT, NodeMCU, glucose monitoring, real-time alerting, Telegram bot, healthcare automation.

I. INTRODUCTION

Intravenous (IV) therapy is a fundamental aspect of medical treatment, where saline bottles are used to deliver fluids, medications, and nutrients to patients. In a busy healthcare environment, manual monitoring of saline levels is prone to human error, which can lead to serious complications if an empty bottle is not replaced on time. To address this challenge, an automated IoT-based monitoring system is designed to track saline levels in real time and notify healthcare staff when intervention is needed.

This paper describes the implementation of a smart saline bottle monitoring system using an ESP8266 WiFi microcontroller, ultrasonic sensors, and Telegram bot notifications. The system continuously measures the saline level using ultrasonic sensors and categorizes it into three states:

1) Normal Level: Sufficient saline in the bottle.
2) Middle Level: Saline is at a warning threshold.
3) Low Level: Immediate replacement required (triggers buzzer and sends a Telegram alert).

The proposed system aims to provide real-time updates, reduce the burden on hospital staff, and ensure timely saline replacement, thereby improving patient safety.

II. LITERATURE REVIEW

Related Works on IoT-Based Medical Fluid Monitoring Several researchers have explored IoT-based monitoring systems to enhance hospital efficiency and ensure patient well-being. Below are some of the related works in this domain:

A. *Smart IV Fluid Monitoring Systems*

P. Gupta et al. (2021) developed an IoT-enabled IV drip monitoring system that utilizes ultrasonic sensors and a microcontroller to measure saline levels. The system sends SMS alerts to healthcare staff when the saline level is low. However, the system lacks a real-time interactive user interface for status checks.

A. Kumar & S. Singh (2022) proposed a system integrating RFID and IoT to track multiple saline bottles in a hospital ward. While the solution provided a scalable approach, the complexity and cost of implementing RFID technology limited its widespread adoption.

H. Li et al. (2020) introduced a weight-based IV monitoring system that measured the decreasing weight of the bottle to estimate fluid levels. This method provided accurate readings but required a specialized load cell, making it less feasible for low-cost implementation.

B. *Wireless Notification Systems for Healthcare*

M. Khan et al. (2021) developed an SMS-based IV monitoring system using GSM modules to alert nurses about saline levels. While effective, the SMS-based approach was costly and had delayed message delivery compared to internet-based solutions like Telegram bots.

B. Roy et al. (2022) proposed an AI-driven IoT healthcare alerting system that uses machine learning algorithms to predict the saline depletion rate. While predictive analytics improved response times, the complexity of data training and deployment made it challenging for small-scale hospitals to adopt.

C. Telegram Bot and IoT Integration

A. Sharma & K. Patel (2023) integrated Telegram bot APIs into an IoT-based home automation system to provide real-time monitoring. The research proved that Telegram provides a fast and reliable method for IoT communication compared to SMS or email notifications.

N. Dey et al. (2021) demonstrated an IoT system that used Telegram bots for remote patient monitoring. Their findings suggested that Telegram's two-way communication capabilities improve user interaction and system accessibility.

III. COMPARATIVE ANALYSIS OF EXISTING SYSTEMS

The proposed system in this research offers cost-effective, real-time, and accurate monitoring by integrating ultrasonic sensors and NodeMCU with Telegram bot notifications, improving over previous SMS-based and RFID-based approaches.

IV. JUSTIFICATION FOR THE PROPOSED SYSTEM

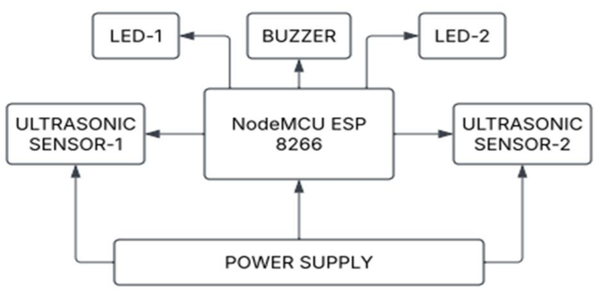
Based on the literature review, the following gaps were identified in existing systems:

1) Delay in Alerting Mechanisms: SMS-based systems often experience message delivery delays.
2) High Cost of Implementation: RFID-based systems are expensive for small-scale hospitals.
3) Lack of User Interaction: Many systems provide only one-way alerts without interactive querying options.
4) Limited Scalability: Weight-based systems require specialized hardware, making them difficult to scale.

The proposed IoT-based glucose monitoring system using ESP8266, ultrasonic sensors, and Telegram bot provides a real-time, cost-effective, and interactive solution by addressing these gaps.

V. PROPOSED SYSTEM

The proposed system aims to monitor the glucose (saline) levels in intravenous (IV) bottles in hospitals and alert medical staff when the bottles reach critically low levels. This system leverages IoT technology using an ESP8266 NodeMCU microcontroller, ultrasonic sensors, and a Telegram bot for real-time monitoring and notifications.



VI. SYSTEM OVERVIEW

A. Hardware Components

1) NodeMCU ESP8266: Microcontroller for processing and communication.
2) Ultrasonic Sensors (HC-SR04): Measure the level of saline/glucose in bottles.
3) Buzzer: Provides an audible alert when the saline level is low.
4) Wi-Fi Network: Connects the system to the internet for remote monitoring.

B. Software Components

1) ESP8266WiFi Library: Enables Wi-Fi connectivity.
2) UniversalTelegramBot Library: Allows communication with Telegram for sending alerts.
3) WiFiClientSecure Library: Ensures secure communication with Telegram API

VII. SYSTEM WORKFLOW

A. *Startup Process*

- The NodeMCU connects to Wi-Fi and initializes sensors.
- The system ensures secure communication with Telegram.

B. *Continuous Monitoring*

- The ultrasonic sensors measure liquid levels periodically.
- If a bottle is low, alerts are sent to the user via Telegram.
- If a bottle is at a middle level, a separate alert is sent.
- The buzzer activates if the liquid level is critically low.

C. *User Interaction via Telegram*

- Caregivers can manually request bottle levels.
- The system responds with real-time distance readings.

D. *Loop Execution*

- The system continuously measures and updates saline levels.
- It checks for new Telegram messages and processes commands.
- The buzzer and notification logic execute as per predefined conditions.

VIII. CHALLENGES AND CONSIDERATIONS

A. *Hardware Challenges*

1) Sensor Accuracy and Placement : Ultrasonic sensor limitations: These sensors may not provide accurate readings for transparent liquids like saline or glucose due to signal reflection issues.
2) Power Management : ESP8266 power limitations: The NodeMCU requires a stable 3.3V power source, and sensors may require 5V.
3) Network Connectivity Issues: Wi-Fi stability: In hospitals or remote areas, network disconnections can affect real-time alerts

B. *Software Challenges*

1) Real-Time Data Processing : Lateny : The system needs to detect and alert instantly.
2) Message Spamming : Frequent alerts: If a bottle level fluctuates near the threshold, it may trigger repeated notifications
3) Security and Data Privacy : Telegram bot token exposure: If the token is leaked, anyone can send messages through the bot.

C. *Deployment and Maintenance Challenges*

1) System Scalability : Multiple devices: If multiple saline/glucose bottles are being monitored, how does the system handle multiple NodeMCUs
2) Long-Term Reliability : Sensor degradation: Ultrasonic sensors may degrade over time.
3) Cloud Integration for Advanced Monitoring : No historical data: The current system only provides real-time alerts but does not store data.

D. *Future Considerations and Improvements*

1) Add a mobile app for better control and visualization.
2) Machine learning for predictive maintenance: Predict when a bottle is likely to run out.
3) Automatic saline/glucose refill system to reduce manual intervention.

IX. FUTURE ENHANCEMENTS

1) Improved Accuracy & Sensor Integration :
2) Advanced Alerting Mechanisms
3) Smart Automation & IoT Integration
4) Enhanced Security & Access Control.

5) Power Efficiency & Reliability
6) AI-Based Predictive Monitoring
7) Multi-Parameter Monitoring

X. CONCLUSION

This IoT-based saline/glucose monitoring and alerting system using NodeMCU provides an efficient and automated method to track the fluid levels in IV bottles. By utilizing ultrasonic sensors, the system accurately measures the fluid level and notifies caregivers via Telegram alerts when the level is low or at a middle threshold. Additionally, a buzzer system ensures an immediate audible alert in case of low levels. This implementation enhances patient safety by reducing the risk of IV depletion and minimizes manual monitoring efforts by hospital staff. The system can be further enhanced with cloud integration, AI-based predictive analytics, and automated IV switching to improve reliability and efficiency.

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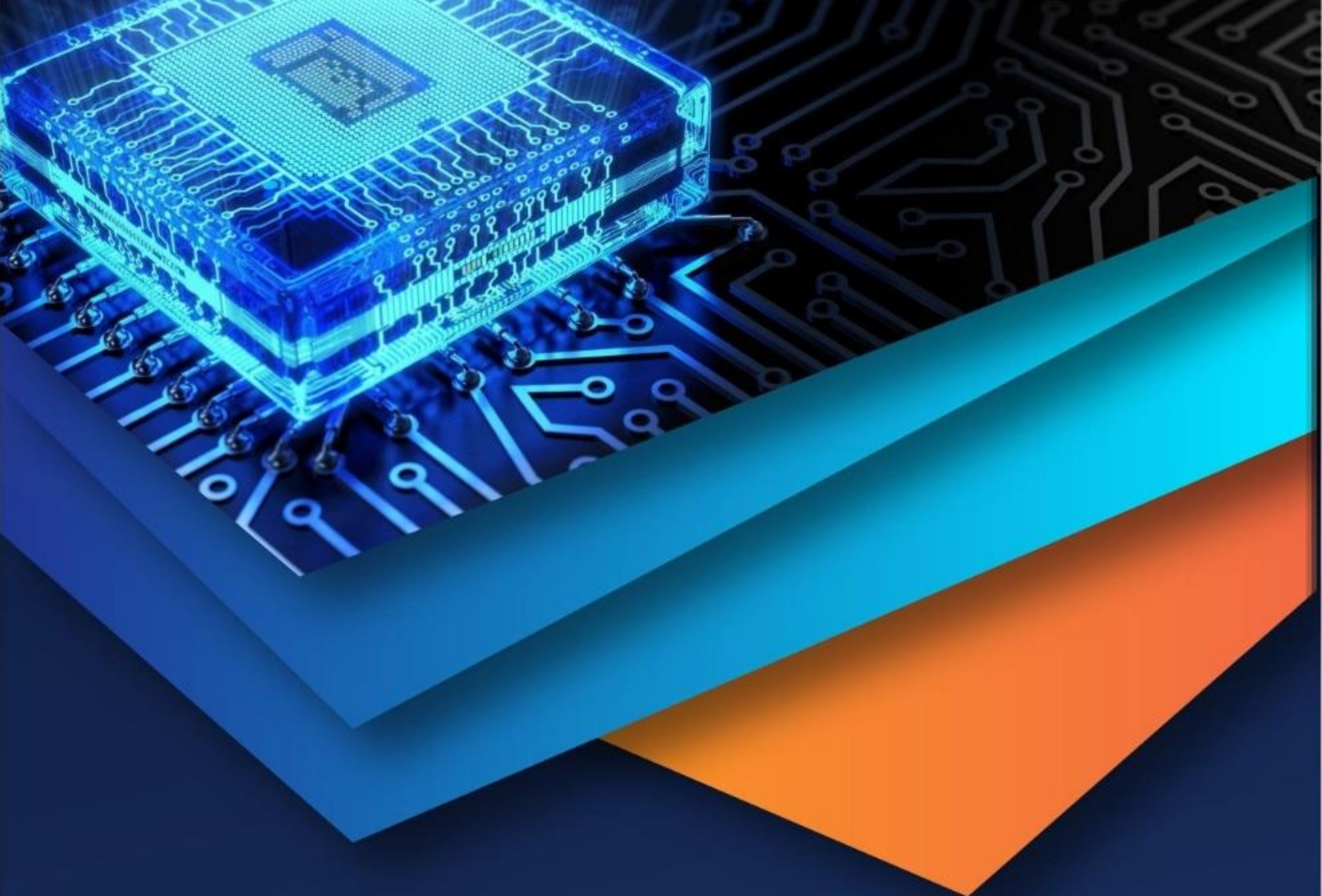

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