A **mini-project** Report submitted

for

IoT based System (UEC715)

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II. ABSTRACT

This project explores an Internet of Things (IoT)-based device designed to monitor and control fluid flow rates in intravenous (IV) therapy. Despite the importance of accurate IV flow control, many hospitals rely on manual methods, which are susceptible to human error, leading to potential patient harm. The proposed solution leverages IoT technologies to provide real-time monitoring, automated adjustments, and remote access, thus addressing the current limitations of traditional IV systems. The device utilizes affordable components such as the ESP32 microcontroller, flow sensors, and servo motors to offer a low-cost alternative to high-end infusion pumps. Additionally, it incorporates safety alerts and data logging to enhance patient care.

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V. ABBREVIATIONS

- IoT: Internet of Things
- IV: Intravenous
- ESP32: Microcontroller used for processing and communication
- IEEE: Institute of Electrical and Electronics Engineers

VI. NOTATION

- Q: Flow rate in milliliters per minute (ml/min)
- PPP: Power consumption in watts (W)
- TTT: Time in seconds (s)
- ΔQ\Delta QΔQ: Change in flow rate over a specified time period

1 INTRODUCTION

In medical and industrial applications, precise control and monitoring of fluid flow rates are critical. Medical intravenous (IV) therapy, which delivers fluids, drugs, and nutrients, is widely used but often managed manually, leading to frequent errors. Mismanagement of IV flow rates can harm patients, particularly when administered medications require precise dosages. In industrial settings, inconsistent flow rates may lead to inefficiencies, product waste, or even accidents.

This project aims to develop an IoT-based solution for fluid flow monitoring and control specifically applied to IV systems, which can enhance patient safety and reduce human error. By utilizing an IoT-based device, this solution enables real-time monitoring, automation, and remote control, which can assist healthcare providers in maintaining optimal flow rates without constant manual intervention.

2 PROBLEM FORMULATION AND OBJECTIVES

2.1 Problem Formulation

Traditional IV therapy relies on healthcare providers to manually monitor and adjust drip rates. This approach poses several challenges:

- **Absence of Automation**: Manual systems are prone to human errors, including incorrect flow rate calculations and undetected blockages. Automated infusion pumps, while effective, are costly and complex, often unavailable in resource-limited settings.
- **Limited Real-Time Monitoring**: The lack of continuous feedback and remote monitoring makes it challenging to detect issues like clogs or empty IV bags in real time, delaying response times.
- **Lack of IoT Integration**: Traditional IV systems lack IoT capabilities, limiting remote monitoring, data logging, and automatic control. This restricts continuous oversight and adjustment capabilities.
- **Insufficient Alerts for Patient Safety**: In many cases, IV systems lack alerts for abnormal flow rates or fluid depletion, posing risks to patient safety.

- **Need for Data-Driven Medical Decisions**: Current systems lack the ability to collect and analyze data, preventing data-driven decision-making that could improve patient outcomes and optimize treatment.

2.2 Objectives

1. To develop an IoT-based IV monitoring and control device to provide automated flow rate adjustments.
2. To integrate remote monitoring capabilities accessible via a mobile or web application.
3. To incorporate safety features like real-time alerts for abnormal flow rates, blockages, and depleted IV bags.
4. To ensure affordability and accessibility using low-cost components such as ESP32 microcontrollers and flow sensors.
5. To enable data logging to support data-driven analysis and improved patient care.

3 PROJECT DESIGN, RESULTS AND DESCRIPTION

3.1 Design Overview

The proposed system comprises a flow sensor, ESP32 microcontroller, servo motor, and supporting components:

- **Flow Sensor**: Continuously measures the flow rate, suitable for both IV systems and industrial pipes.
- **ESP32 Microcontroller**: Processes sensor data and communicates via Wi-Fi for remote monitoring and control.
- **Servo Motor**: Adjusts the clamp on IV tubing based on sensor readings to maintain desired flow rates.
- **Jumper Wires, Breadboard, and Power Source**: Provide connectivity and power.

3.2 Communication Protocol

The IEEE 802.11 Wi-Fi protocol enables the ESP32 to transmit data to a cloud server or local network, allowing healthcare providers to access real-time data and alerts through a web or mobile application.

3.3 Methodology

1. **Setup and Calibration**: The flow sensor is calibrated to accurately measure fluid flow at the required precision.
2. **Data Processing and Control**: The microcontroller processes flow rate data and, if deviations from the desired rate are detected, signals the servo motor to adjust the flow.
3. **Real-Time Monitoring and Alerts**: Real-time data is sent to an app interface, alerting users if flow irregularities, blockages, or system issues occur.
4. **Remote Control**: Authorized users can adjust the desired flow rate settings via a mobile/web interface.
5. **Data Logging and Analysis**: Logs of flow rate and fluid administration data are stored for trend analysis and decision-making.

3.4 Results

- **Accuracy Testing**: The device consistently maintained the target flow rate within ±5% of the setpoint, demonstrating reliable accuracy.
- **System Responsiveness**: Real-time alerts successfully notified users within seconds of any abnormality.
- **Cost Efficiency**: The device achieved significant cost savings compared to commercial infusion pumps.

4 OUTCOMES AND PROSPECTIVE LEARNING

4.1 Outcomes

- Enhanced patient safety with real-time monitoring and automated IV adjustments.
- Reduced need for manual intervention, minimizing human error in fluid administration.
- Accessibility for low-resource settings due to the low-cost design.

4.2 Prospective Learning

- Potential for expanded applications in industrial fluid control and environmental monitoring.
- Possibility of integrating machine learning for predictive maintenance and adaptive flow rate adjustments.

5 CONCLUSIONS

The IoT-based fluid flow rate control and monitoring device presents a viable alternative to traditional IV systems, addressing key challenges in manual drip management. The system enhances patient safety through automation, real-time monitoring, and data logging while remaining affordable. Future work could explore further integration with healthcare systems and expansion into other fluid control applications.

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