IOT Based Automated IV Bag Monitoring System

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ABSTRACT

The growing demand for automation in healthcare has led to the development of an IoT-based Automated IV Bag Monitoring System. This system utilizes sensors to monitor IV bag weight and environmental conditions like room temperature and humidity, ensuring patient safety and comfort. A servo motor mechanism, equipped with a clip, is employed to halt IV fluid flow automatically when the bag is empty, minimizing the risk of complications. Alerts and notifications are sent via the Blynk IoT platform, providing real-time updates to caregivers through mobile and web interfaces. The system aims to enhance healthcare efficiency by automating IV management, offering timely alerts for low IV fluid levels, and ensuring environmental conditions are maintained within comfort ranges.

Keywords—IoT, IV bag monitoring, healthcare automation, ESP8266, Blynk platform, HX711 load cell, DHT11 sensor, patient care, smart healthcare, real-time alerts, remote monitoring, room temperature monitoring, fluid level detectio

I. INTRODUCTION

The growing need for automation in healthcare has inspired the development of an Advanced Automated IV Bag Monitoring System. This system incorporates sensors, actuators, and the Blynk IoT platform to monitor IV bag weight and environmental conditions, such as room temperature and humidity. Additionally, it employs a servo motor with a clip mechanism to automatically halt the IV fluid flow when the bag is empty, minimizing risks associated with delayed intervention. Real-time alerts are sent to caregivers via the Blynk platform when critical conditions, such as an empty IV bag or extreme temperature levels, are detected. This innovation ensures improved patient safety, enhances comfort, and enables more efficient healthcare management.

II. LITERATURE REVIEW

The study by V. Arunvikas, et al.[1], published by IEEE, addresses challenges in IV fluid monitoring through an IoT-enabled Patient Monitoring System on Intravenous Fluid. The system automates IV fluid level tracking to prevent complications like blood backflow, a common issue due to nurses' busy schedules. Key components include a DHT11 sensor for temperature monitoring, a heart rate sensor for cardiovascular data, and an ultrasonic sensor to track IV drip rates (1 cm/min). An ESP8266 microcontroller enables real-time data transmission to an Android app, allowing remote monitoring. An emergency stop button adds a safety feature for immediate alerts. This innovative system enhances healthcare efficiency by automating critical tasks and reducing reliance on manual intervention. While promising, further research is needed to assess its practicality in hospital settings and explore features like automated IV shut-off mechanisms.

III. METHODOLOGY

A. Overview

The proposed system integrates multiple components to achieve automated IV bag monitoring and real-time notification. The core functionalities are implemented using the ESP8266 microcontroller, with the following sensors and actuators:

- **HX711 Load Cell:** Measures the weight of the IV bag to determine fluid levels.
- **DHT11 Sensor:** Monitors room temperature and humidity to ensure patient comfort.
- **Servo Motor with Clip Mechanism:** Automatically halts the IV fluid flow by closing the IV line when the bag is empty, preventing risks associated with overuse.
- **Buzzer and LEDs:** Provides audio-visual alerts to indicate different conditions, such as a nearly empty or empty IV bag.
- **Blynk IoT Platform:** Displays real-time data and sends automated notifications, including critical alerts, to caregivers via mobile apps or a web dashboard.

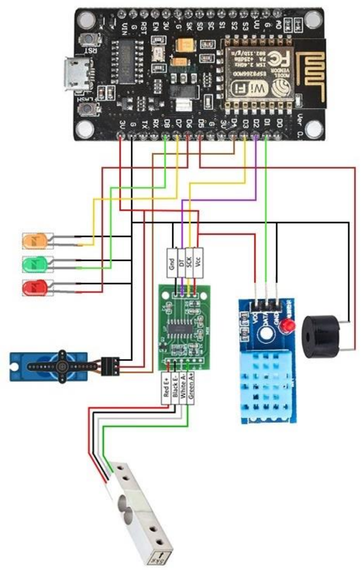

Figure: Workflow Diagram

B. Component-wise Description

1. ESP8266 Microcontroller

The core processing unit that handles sensor data and controls the actuators. It also connects to the Blynk IoT platform for remote monitoring and notifications.

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2. Components and Pin Connections

Sensors

1. **HX711 Load Cell Module** (Used to measure the weight of the IV bag)
   a. **DT Pin** → ESP8266 Pin **D2**
   b. **CLK Pin** → ESP8266 Pin **D3**
2. **DHT11 Sensor** (Monitors room temperature and humidity)
   a. **DATA Pin** → ESP8266 Pin **D1**
   b. **VCC** → ESP8266 **3.3V**
   c. **GND** → ESP8266 **GND**

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3. Actuators

1. **Servo Motor with Clip Mechanism (Controls IV fluid flow):**
   - **Signal Pin** → ESP8266 Pin D4
   - **VCC** → ESP8266 3.3V
   - **GND** → ESP8266 GND
2. Buzzer **(Provides audio alerts)**
   a. Signal Pin → **ESP8266 Pin** D5
   b. VCC → **ESP8266** 3.3V
   c. GND → **ESP8266** GND
3. LED Indicators **(Provide visual alerts based on IV bag status)**
   a. Red LED → **ESP8266 Pin** D6
   b. Yellow LED → **ESP8266 Pin** D7
   c. Green LED → **ESP8266 Pin** D8
   d. All LEDs**: Connected with a resistor to avoid overcurrent.**

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3. Connectivity

- **WiFi**: ESP8266 connects to the local WiFi network using the credentials:
  - SSID: "Home"
  - Password: "22335577"
- **Blynk IoT Platform**:
  - Template ID: TMPL6JUXCBgUY
  - Template Name: Automated IV Bag
  - Auth Token: 1KkzEIK80TfxBaXnwWRCXvx34BgJs6Eq

D. Functionality Overview

1. **Initialization**:
   - Calibrates the load cell using a known weight.
   - Initializes the DHT11 sensor, LEDs, and buzzer.
2. **IV Bag Weight Monitoring**:
   - Continuously measures the IV bag's weight via the load cell.
   - Activates:
     - **Green LED**: Normal state.
     - **Yellow LED**: Almost empty state (weight between 0.05–0.06 kg).
     - **Red LED**: Empty state (weight ≤ 0.01 kg).
   - Sends weight data to **Blynk (V2)**.
3. **Temperature and Humidity Monitoring**:
   - Reads temperature and humidity from DHT11.
   - Sends temperature to **Blynk (V0)** and humidity to **Blynk (V1)**.
   - Triggers an alert if the temperature exceeds 32°C.
4. **Alerts**:
   - **Buzzer**: Activates in cases of:
     - IV bag nearing empty or empty.
     - Room temperature exceeding 32°C.
   - **Blynk Notifications**: Sends warnings (e.g., IV bag empty or temperature alert).

IV. RESULT ANALYSIS

The result analysis evaluates the system's overall performance, emphasizing the effectiveness of the modifications.

A. NodeMCU ESP8266

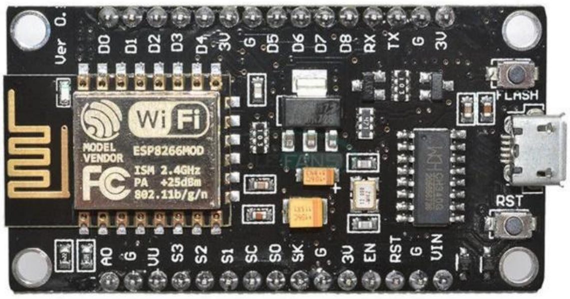


Figure: NodeMCU

- **Purpose**:
  - Acts as the central control unit of the system.
  - Reads sensor data, processes it, and drives the actuators (buzzer and LEDs).
  - Handles Wi-Fi connectivity for remote monitoring via the Blynk platform.
- **Features Utilized**:
  - GPIO pins for interfacing with sensors and actuators.
  - Wi-Fi module for IoT integration.
  - ADC for digital signal processing (via the HX711 module).

B. HX711 Load Cell (Sensor)

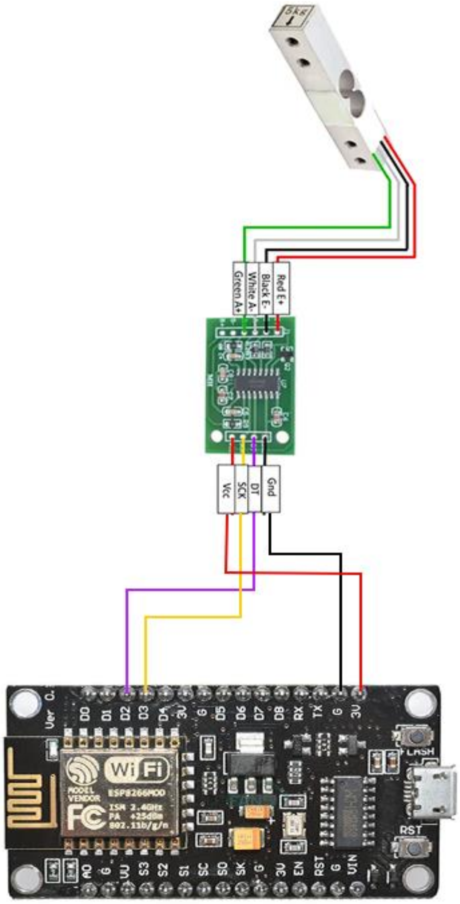


Figure: Connect weighing sensor via hx711 with nodemcu

- **Purpose**: Measures the weight of the IV bag to monitor the fluid level.
- **Functionality**:
    - The load cell outputs an analog signal proportional to the weight applied.
    - The HX711 ADC (Analog-to-Digital Converter) converts this signal into a digital value for the ESP8266.
    - Calibrated using a known weight to compute an accurate scale factor.
- **How It Works**:
    - Measures the weight and converts it to a meaningful value (e.g., kilograms).
    - Alerts caregivers when the IV bag is almost empty or fully empty.
- **Result**:
    - Provides highly accurate weight measurements when properly calibrated.
    - Reacts to specific weight thresholds (`<=0.01 kg` for empty, `0.05-0.06 kg` for almost empty).
    - Properly activates the servo motor to control the IV flow when the bag is empty.
- **Performance Analysis**:
    - **Strength**: Highly sensitive and precise.
    - **Potential Issues**: Accuracy depends on proper calibration; may be affected by noise or vibrations.

C. DHT11 Sensor (Sensor)

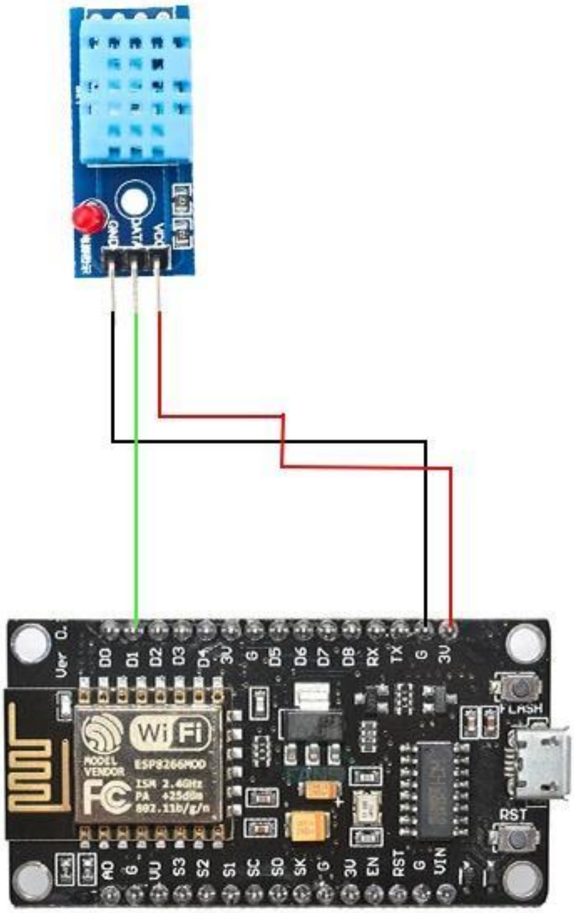


Figure: Connect DHT11 sensors with nodemcu

- **Purpose**: Monitors room temperature and humidity to ensure patient comfort.
- **Functionality**:
    - Measures temperature (in °C) and humidity (in %).
    - Sends the data to the Blynk app for remote monitoring.
    - Triggers a buzzer alert if the temperature exceeds 32°C.
- **How It Works**:
    - Continuously reads temperature and humidity.
    - Reports values to the serial monitor and sends them to virtual pins on Blynk.
- **Result**:
    - Accurate within its limits: ±2°C for temperature and ±5% for humidity.
    - Alerts caregivers if the environment becomes too warm.
- **Performance Analysis**:
    - **Strength**: Simple and reliable for basic environmental monitoring.
    - **Limitation**: Not highly precise; can struggle in extreme conditions or high humidity.

D. Buzzer (Actuator)

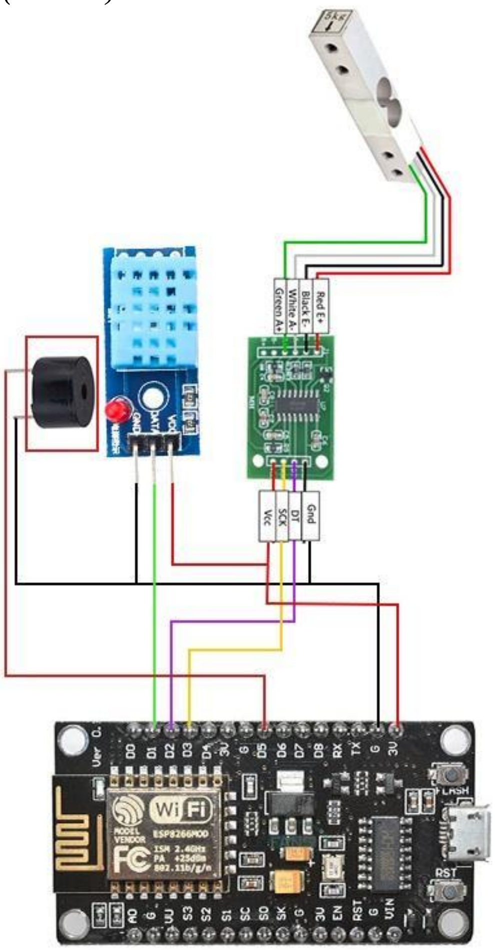
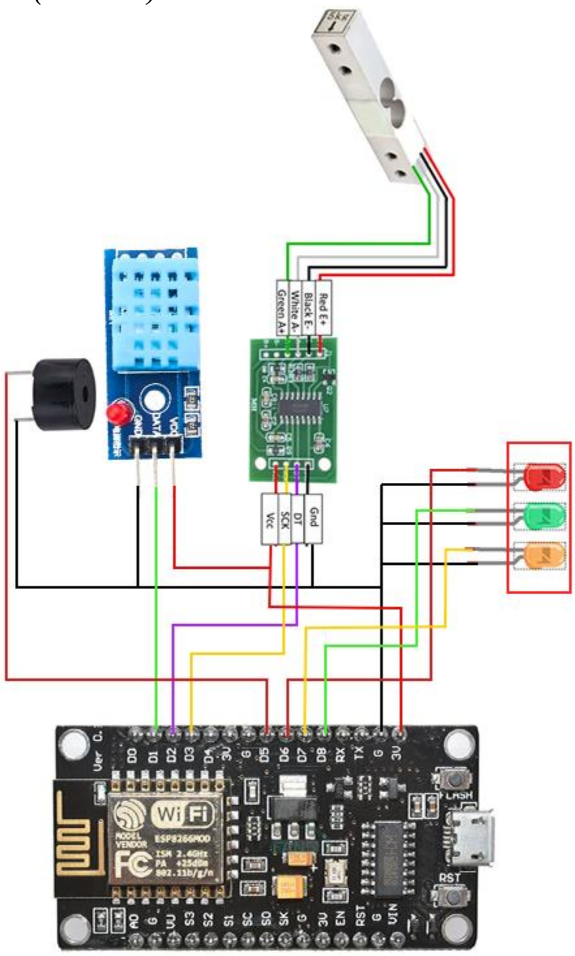


Figure: Connect Buzzer with nodemcu

- **Purpose**: Provides audio alerts for critical situations.
- **Functionality**:
  - Emits a sound when:
    - The IV bag is almost empty.
    - The IV bag is empty.
    - The room temperature exceeds 32°C.
- **How It Works**:
  - The buzzer pin is toggled HIGH for 500ms to generate a beep.
- **Result**:
  - Alerts caregivers immediately through sound, ensuring attention to critical situations.
- **Performance Analysis**:
  - **Strength**: Effective for immediate audio notifications.
  - **Limitation**: May be overlooked in noisy environments.

E. LEDs (Actuators)



- **Purpose**: Provide a visual indication of the IV bag's status.
- **Functionality**:
  - **Green LED**: Lit when the IV bag is in a normal state (weight > 0.06 kg).
  - **Yellow LED**: Lit when the IV bag is almost empty (weight between 0.05–0.06 kg).
  - **Red LED**: Lit when the IV bag is empty (weight ≤ 0.01 kg).
- **How It Works**:
  - The appropriate LED is turned on based on the weight thresholds.
  - Other LEDs are turned off to avoid confusion.
- **Result**:
  - Provides clear and immediate visual feedback for caregivers.
- **Performance Analysis**:
  - **Strength**: Intuitive and easy to interpret at a glance.
  - **Limitation**: Visibility may reduce in brightly lit environments.

F. Servo Motor (Actuator)

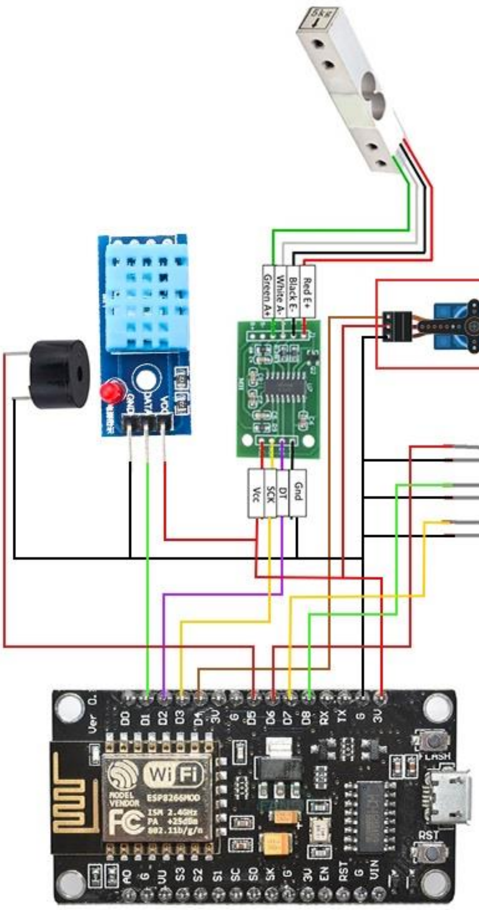


Figure: Connect Servo Motor with NodeMCU

● **Purpose:** Automatically stops the IV fluid flow when the IV bag is empty by pressing the IV tube using a clip mechanism.

● **Functionality:**
  - Moves to specific angles to control the flow of IV fluid:
    - **Normal State:** Remains in the default position (180°) to allow fluid flow.
    - **Critical State:** Moves to 0° to press the clip and stop fluid flow when the IV bag is empty.

● **How It Works:**
  - Controlled via the servo signal pin connected to NodeMCU.
  - Servo angle is adjusted programmatically based on the weight of the IV bag.

● **Result:**
  - Automatically cuts off fluid flow in critical situations, ensuring patient safety.

● **Performance Analysis:**
  - **Strength:** Provides a fully automated and precise response to critical conditions, eliminating the need for manual intervention.
  - **Limitation:** Requires a reliable power supply and calibration for consistent operation.

G. Blynk IoT Platform

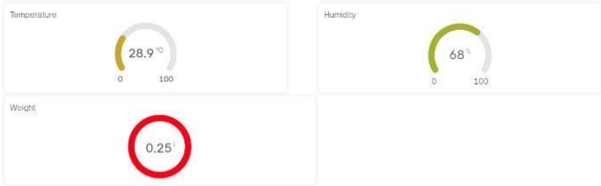


Figure: Blynk Web Dashboard

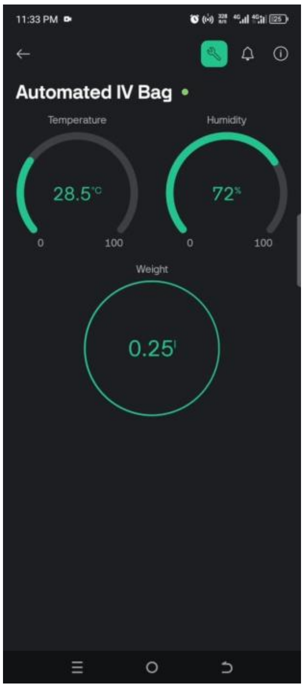


Figure: Blynk Mobile Dashboard

- **Purpose**: Enables remote monitoring and notification delivery.
- **Functionality**:
  - Sends weight, temperature, and humidity data to the Blynk app (via virtual pins).
  - Triggers notifications (e.g., "IV bag almost empty," "Temperature exceeds 32°C") to caregivers.
- **How It Works**:
  - Continuously updates virtual pins with sensor data.
  - Sends alerts via **Blynk.logEvent()** for critical thresholds.
- **Result**:
  - Provides real-time updates and alerts to caregivers, even when they are away from the system.
- **Performance Analysis**:
  - **Strength**: Extends system usability through remote access.
  - **Limitation**: Relies on a stable WiFi connection and the Blynk platform's uptime.

H. System Summary

Component	Purpose	Result	Performance
HX711 Load Cell	Weight measurement	Accurately detects IV bag weight changes.	High sensitivity; requires proper calibration.
DHT11 Sensor	Temperature & humidity monitoring	Provides basic environmental readings.	Reliable within its range; limited precision.
Buzzer	Audio alerts	Beeps in critical situations.	Clear notification; may be missed in noisy areas.
LEDs	Visual alerts	Indicates IV bag status using color codes.	Easy to understand; visibility depends on lighting.
Servo Motor	Automates IV fluid flow control by physically pressing the IV tube when the IV bag is empty.	Effectively stops fluid flow during critical conditions, ensuring patient safety.	Provides precise and reliable control; dependent on proper calibration and consistent power supply.
Blynk Platform	Remote monitoring & notifications	Updates and alerts caregivers remotely.	Great for remote access; dependent on internet stability.

I. HARDWARE AND SOFTWARE OUTPUTS

1. Normal Operating State

The system is in a **normal state** where all conditions are within safe thresholds:

1. **Temperature:** The room temperature is below 32°C, as monitored by the DHT11 sensor.
2. **IV Bag Weight:** The IV bag has more than 60 ml of fluid, measured using the HX711 load cell.

System Indicators:

- The **green LED** is lit, indicating normal operating conditions.
- No buzzer is activated, as there are no critical alerts.
- The Blynk IoT dashboard displays:
    - Room temperature and humidity within safe ranges.
    - IV bag status as "Normal."

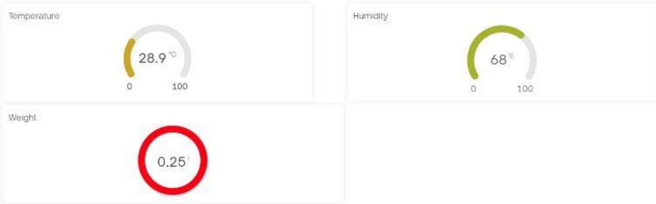


Figure: Blynk Web Dashboard (Normal Stage)

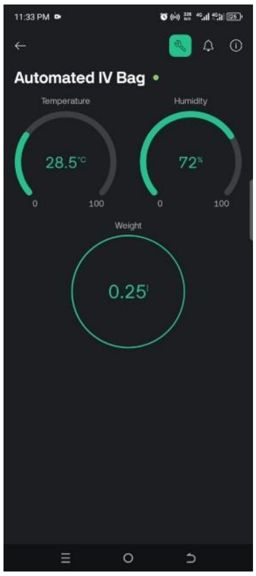


Figure: Blynk Mobile Dashboard (Normal Stage)

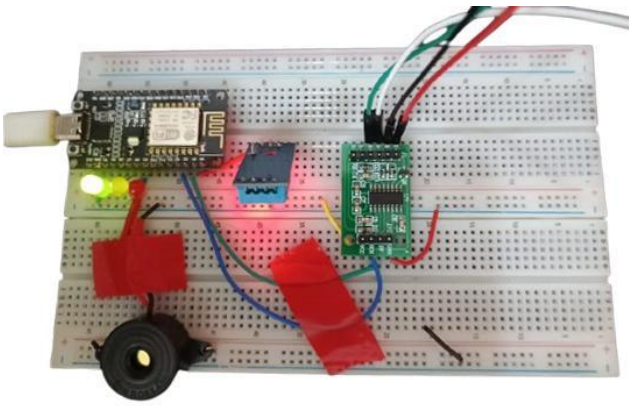


Figure: Hardware Setup in Normal Condition (Green LED ON)

2. Critical Operating State

The system is in a critical state where one or more conditions have crossed unsafe thresholds:

- **Temperature:** The room temperature is 32°C or higher, as detected by the DHT11 sensor.
- **IV Bag Weight:** The IV bag is empty or near empty, with a weight below the critical threshold, measured by the HX711 load cell.

System Indicators:

- The red LED is lit, signaling a critical condition.
- The buzzer is activated, providing an audible alert for immediate attention.
- The Blynk IoT dashboard displays:
    - A high room temperature warning.
    - The IV bag status as "Empty."
    - A notification sent to the caregiver's mobile app for prompt action.

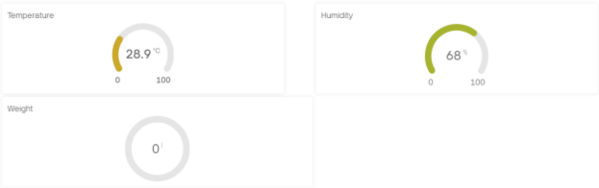


Figure: Blynk Web Dashboard (Critical Stage)

Figure: Blynk Web Dashboard (Critical)

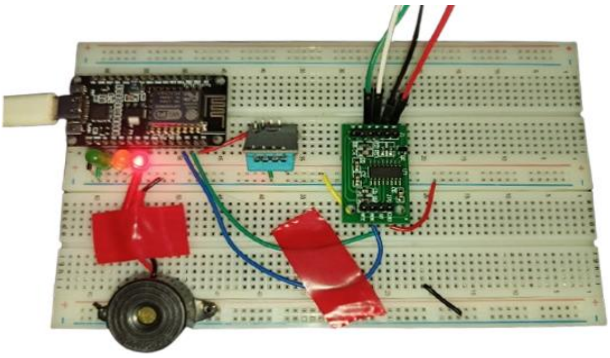


Figure: Hardware Setup in Critical Condition (RED LED ON)

3. Full Project Preview

Figure: Full Project Preview

V. Conclusion

The IoT-Based Automated IV Bag Monitoring System effectively combines sensors, actuators, and IoT technology to enhance patient safety and healthcare efficiency. The system automates the monitoring process by accurately measuring the IV bag's weight and environmental factors like room temperature and humidity in real time. The addition of a servo mechanism to automatically clamp the IV tube when the bag is empty ensures a higher level of patient safety by preventing risks such as blood backflow.

Visual indicators (LEDs), auditory alerts (buzzer), and automated notifications via the Blynk IoT platform provide caregivers with timely and actionable information, enabling swift responses to critical conditions. This integration of automation highlights the potential of IoT in revolutionizing healthcare practices, making essential monitoring tasks more reliable, efficient, and patient-focused.

Limitations

1. **Servo Precision**: The servo motor used for clamping the IV tube may require regular calibration to ensure effective operation and prevent leaks.
2. **Dependency on Internet Connectivity**: The system relies on a stable internet connection to communicate with the Blynk IoT platform, limiting functionality in areas with poor connectivity.
3. **Fixed Thresholds**: The system uses predefined thresholds for weight and temperature, which may not be ideal for all patients without additional customization.
4. **Sensor Limitations**: The DHT11 sensor and HX711 load cell may have limited accuracy, potentially affecting the precision of temperature, humidity, and weight measurements.
5. **Noise Sensitivity**: The buzzer alert may not be effective in noisy environments, requiring additional alert mechanisms like vibrations or stronger audio signals.

Future Plans

1. **Enhanced Servo Automation**: Optimize the servo mechanism to improve accuracy and reliability in clamping the IV tube when critical thresholds are reached.
2. **Integration of Advanced Sensors**: Include additional sensors, such as heart rate and oxygen saturation monitors, to provide a more comprehensive patient health overview.
3. **Customizable Alerts**: Develop a user interface to allow caregivers to set custom thresholds for IV bag weight, temperature, and humidity, adapting the system to individual patient needs.
4. **Battery Backup and Fail-Safe Mechanisms**: Add a battery backup to ensure uninterrupted operation during power outages and fail-safe mechanisms for servo-based IV cutoff.
5. **Offline Functionality**: Introduce local data storage and offline alert systems, reducing reliance on continuous internet connectivity while maintaining basic functionality.
6. **Scalability**: Expand the system's capability to monitor and manage multiple IV bags simultaneously, making it suitable for larger healthcare facilities and hospitals.
7. **Data Analytics**: Enable the system to record historical data for analysis, offering insights into patient care trends and enabling predictive maintenance of equipment.

References

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