National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

INTERNET OF THINGS

PROJECT REPORT

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Smart Irrigation System

1. Introduction

Water management is a critical concern in agriculture, where efficient irrigation can significantly improve productivity while conserving water resources. Traditional irrigation systems rely on manual control and are often prone to inefficiencies and overuse of water. To address this challenge, we developed a **Smart Irrigation System**, leveraging Internet of Things (IoT) technologies, cloud computing, and machine learning to automate irrigation processes.

This system utilizes sensors to monitor environmental parameters such as soil moisture, humidity, and rain presence. Data collected by these sensors is processed by a machine learning model deployed on the **Microsoft Azure Cloud**. The model predicts whether the irrigation pump should be turned ON or OFF, optimizing water use. Additionally, the system integrates the **Blynk IoT platform** for real-time visualization and remote control, allowing users to monitor system performance and adjust via a mobile app.

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2. System Components and Sensors

2.1 Sensors and Related Components

1. **Soil Moisture Sensor**
    - **Function**: Measures soil water content to determine dryness or wetness.
    - **Specifications**:
        - Operating Voltage: 3.3V–5V
        - Output: Analog signal

2. **DHT11 Sensor**
    - **Function**: Monitors ambient temperature and humidity.
    - **Specifications**:
        - Humidity Range: 20%–80% RH
        - Temperature Range: 0–50°C
        - Output: Digital signal

3. **Rain Sensor**
    - **Function**: Detects the presence of rain to determine the need for irrigation.
    - **Specifications**:
        - Operating Voltage: 3.3V–5V
        - Output: Digital signal

4. **Relay Module**

- **Function**: Controls the water pump based on predictions received from the cloud.

5. **Development Board: ESP32**
   - **Justification**:
     - Built-in Wi-Fi for cloud communication
     - Power-efficient design suitable for IoT applications
     - Adequate GPIO pins for sensor integration

6. **Liquid Crystal Display (LCD)**
   - **Function**: Displays sensor data, predictions, and system status.

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3. System Design and Circuit Diagram

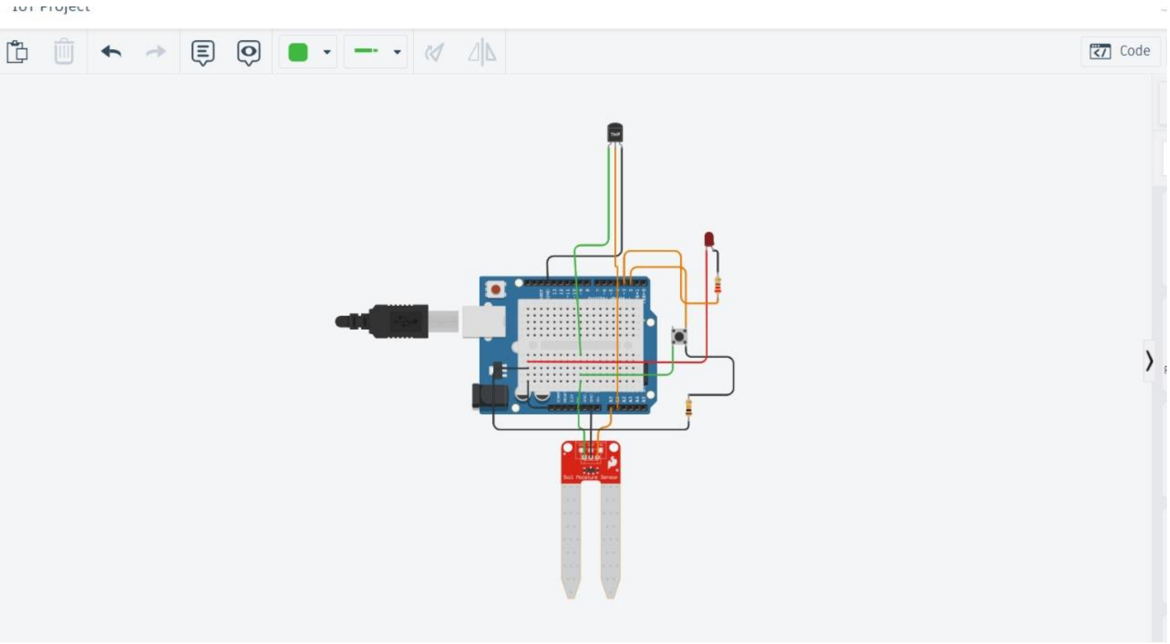
3.1 Design Overview

The system's core component is the ESP32 microcontroller, which collects data from sensors, processes predictions from the Azure cloud API, and controls the water pump via a relay.

3.2 Circuit Diagram

The circuit connects:

1. Soil Moisture Sensor to an analogue input pin on ESP32.
2. DHT11 Sensor and Rain Sensor to digital input pins.
3. Relay module to control the pump via a digital output pin.
4. LCD to display system information using I2C communication.



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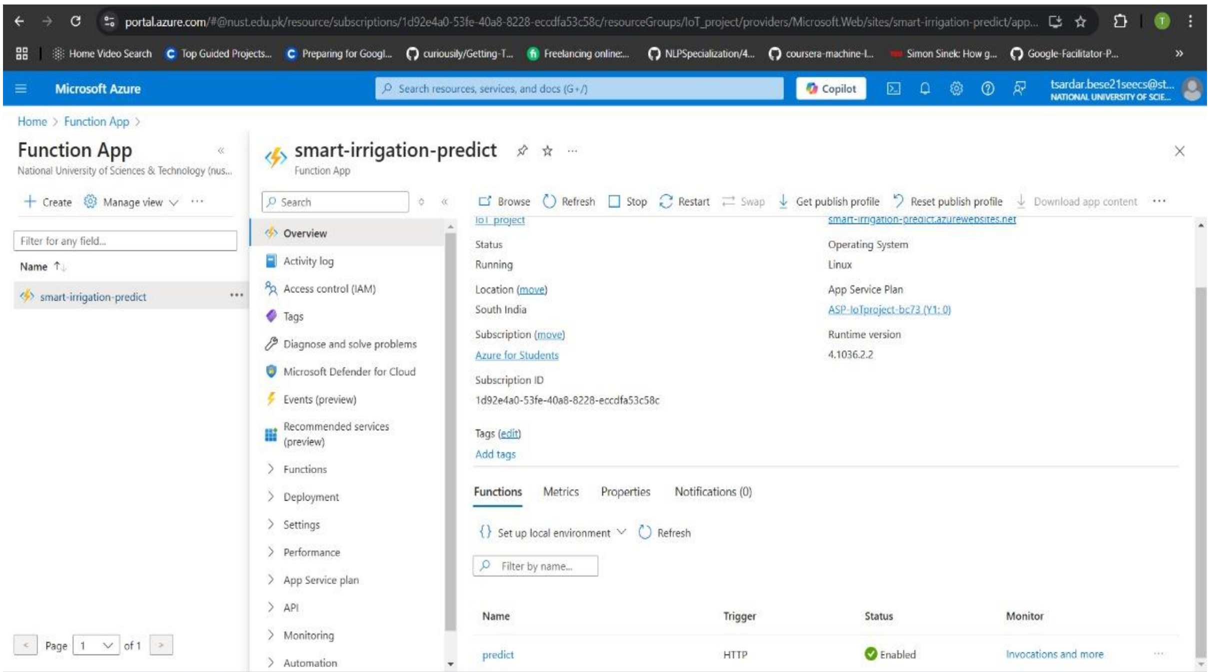
4. Cloud Integration Using Azure API

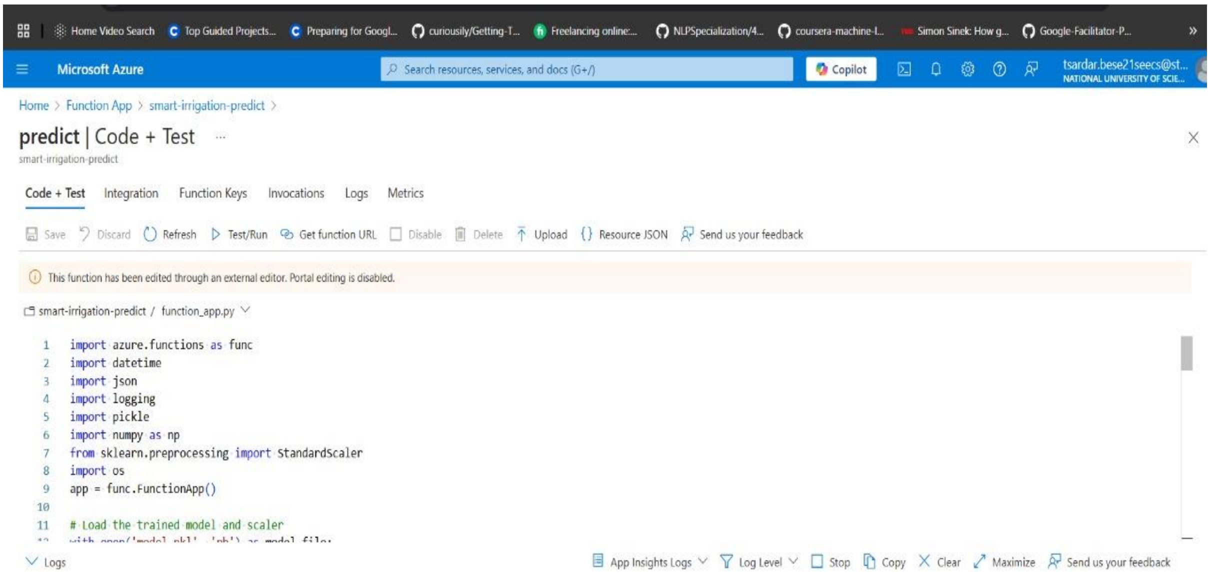
4.1 Cloud Integration

The Microsoft Azure platform hosts a trained ML model exposed via a REST API. The API processes real-time data from sensors and predicts irrigation requirements.

4.2 Cloud Workflow

1. The ESP32 sends sensor data as a JSON payload to the Azure API.
2. The ML model processes the data and returns predictions in JSON format.
3. The ESP32 parses the response and controls the pump accordingly.





5. Communication Technology

5.1 Layers and Technologies

1. **Physical Layer**:
   - Wireless communication through the ESP32’s Wi-Fi module.
2. **Internet Layer**:
   - HTTP protocol for communication between the ESP32 and Azure API.
3. **Application Layer**:
   - Blynk platform for data visualization and control.

5.2 Network Topology

- **Topology**: Star Topology
  - The ESP32 acts as a central node, connecting sensors, the cloud API, and the Blynk IoT platform.

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6. Blynk IoT Integration

6.1 Overview of Blynk

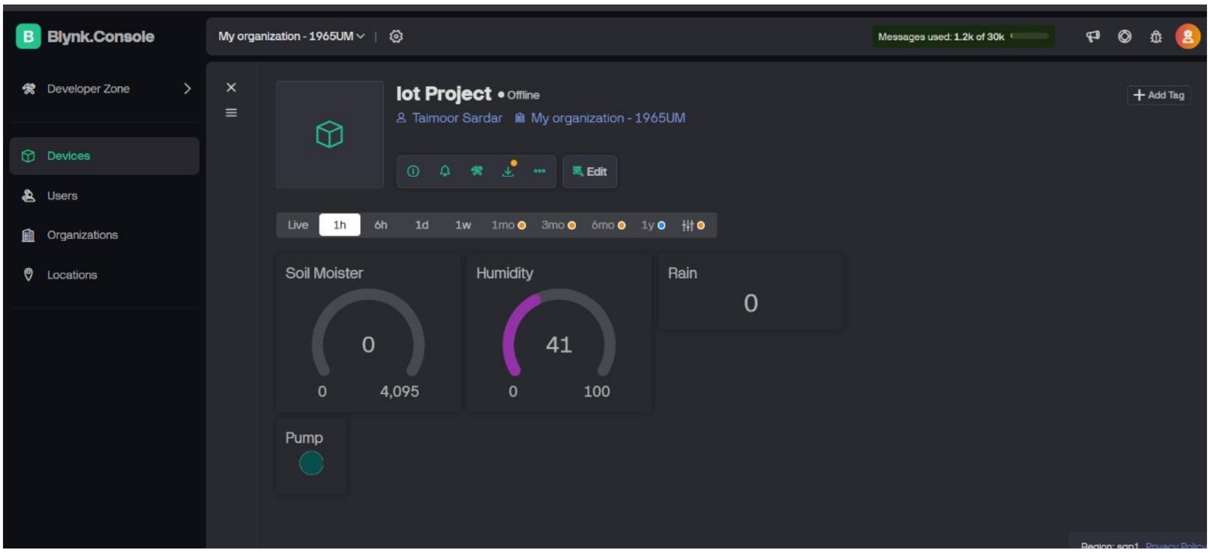
Blynk is a user-friendly IoT platform that allows users to monitor and control their IoT devices via a mobile app. It provides real-time data visualization, control mechanisms, and customizable dashboards for various IoT projects.

6.2 Features Used in the Project

1. **Real-Time Data Visualization**:
   - Sensor readings, including soil moisture, humidity, and rain status, are displayed on the Blynk app dashboard using widgets like gauges and graphs.
2. **Remote Control**:
   - The user can remotely monitor and control the water pump via the app.
3. **Alerts and Notifications**:
   - Blynk can send notifications when critical conditions, such as extremely low soil moisture, are detected.
4. **Customizable Dashboard**:
   - Widgets such as LEDs, buttons, and sliders are configured for real-time updates.

6.3 Blynk Dashboard Configuration

- **Widgets Added**:
  - Gauge for soil moisture.
  - Bar graph for humidity.
  - Button for rain detection.
  - LED indicator for pump status.



7. Data Analysis

7.1 Descriptive Analytics

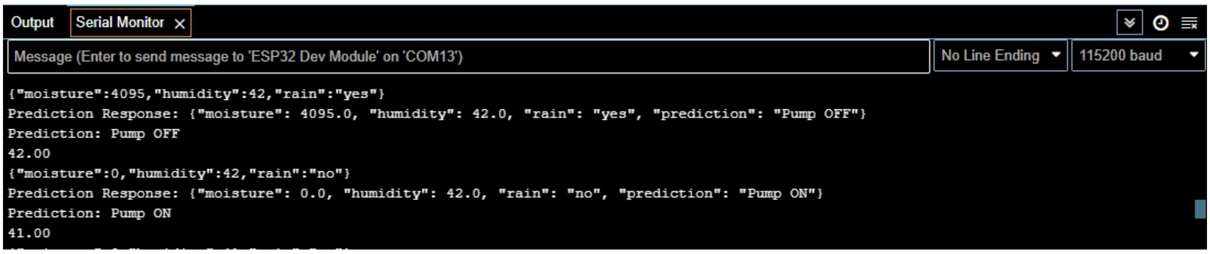
Real-time data trends are visualized on the Blynk app to provide an overview of environmental conditions.

7.2 Diagnostic Analytics

Analyses sensor data patterns to detect anomalies, such as irregular soil moisture levels, which could indicate faulty sensors or extreme weather conditions.

7.3 Predictive Analytics

The Azure ML model predicts irrigation needs based on historical and current sensor data, optimizing water use.



8. Power Consumption Analysis

8.1 Sensor Power Consumption

Component	Power Consumption
Soil Moisture Sensor	~20mA
DHT11 Sensor	~2.5mA

Rain Sensor	~3mA
ESP32 (Active Mode)	~200mA
Relay Module	~70mA

8.2 Optimization Strategies

- Enabled deep sleep mode on the ESP32 when idle.
- Optimized sensor sampling rates to reduce power consumption.

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9. Git for Team Collaboration

9.1 Repository Management

A GitHub repository was created for version control and collaboration. All team members contributed code and documentation incrementally.

9.2 Workflow

- **Branches**: Separate branches for hardware integration, cloud communication, and visualization.
- **Commit Logs**: Updates with detailed messages for clarity.

GitHub URL: https://github.com/taimoorsardar/Smart-Irrigation-System.git

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10. Conclusion

The **Smart Irrigation System** integrates IoT, cloud computing, and machine learning to deliver an intelligent and user-friendly solution for modern agriculture. With real-time data visualization via the Blynk app and accurate predictions from the Azure ML model, this system ensures efficient water usage and sustainable farming practices. Its modular design and scalability make it suitable for both small-scale and large-scale agricultural applications.