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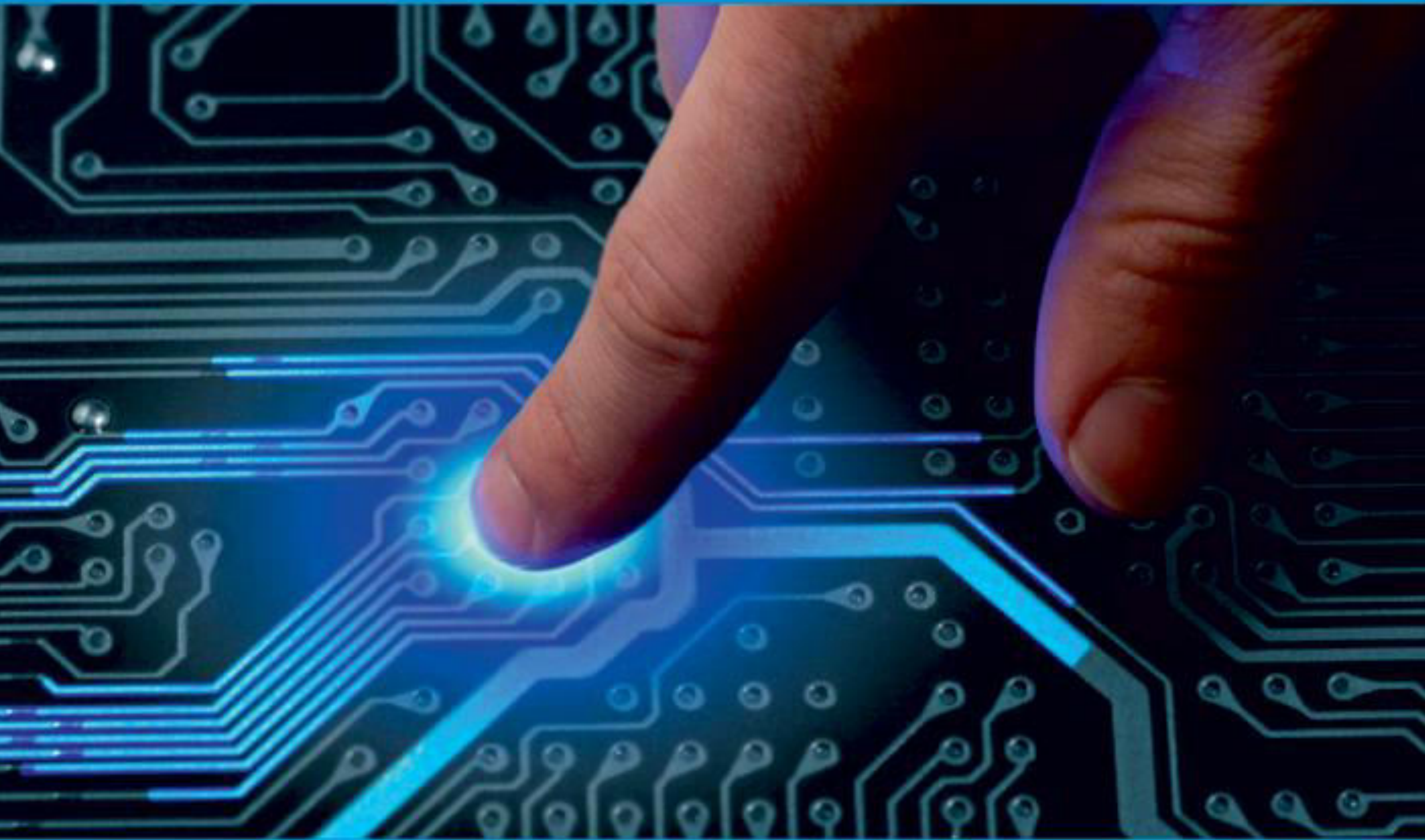

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IOT-based Greenhouse Monitoring System

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ABSTRACT: The agricultural sector is increasingly integrating technology to boost productivity and sustainability. A notable advancement is the adoption of the Internet of Things (IoT) in greenhouse management, utilizing sensors, actuators, and data analytics to optimize environmental conditions for plant growth. This paper proposes an IoT-based greenhouse monitoring system enhanced with voice recognition technology, offering a hands-free, user-friendly interface for farmers. The system continuously monitors humidity and temperature using DHT22, addressing the limitations of traditional manual monitoring, which can be labor-intensive and prone to errors. Sensor data is transmitted to an IoT(Arduino MKR WiFi 1010 board) platform for processing, enabling automated control of irrigation, ventilation, and lighting systems. The recorded data is stored in a cloud database (ThingSpeak) and displayed on a web page for easy access.The integration of a voice recognition module allows users to interact verbally with the system, issuing commands like adjusting temperature or starting irrigation without manual input. Additionally, remote monitoring and control via mobile or web applications enhance usability and decision-making. This intelligent system reduces labor and increases crop yield by creating a responsive greenhouse management environment.

KEYWORDS: Voice recognition; Arduino MKR WiFi 1010 board; temperature and humidity sensors.

I.INTRODUCTION

In recent years, the agricultural sector has increasingly embraced technology to enhance productivity and sustainability. One significant advancement is the integration of the Internet of Things (IoT) into greenhouse management. An IoT-based greenhouse monitoring system leverages sensors, actuators, and data analytics to optimize environmental conditions for plant growth. These systems enable real-time monitoring of key parameters such as temperature, humidity, soil moisture . By collecting and analyzing this data, farmers can make informed decisions that lead to improved crop yields, reduced resource consumption, and enhanced operational efficiency. Furthermore, the remote accessibility of these systems allows for prompt adjustments and alerts, ensuring that optimal conditions are maintained.

This introduction outlines the importance of IoT in modern agriculture, the components of a typical greenhouse monitoring system, and the benefits it offers to farmers and the environment. As we explore this technology, it becomes evident that IoT solutions are not only transforming greenhouse management but also paving the way for a more sustainable agricultural future.Our main motive to develop a project is to have advancement of technology in agriculture and promoting the use of greenhouse widely across the country. Our project focus on creating a IOT based greenhouse monitoring system which mainly focus on creating a user friendly smart IoT Based Humidity and Temperature Monitoring Using Arduino Uno , Using Internet of Things (IOT) we can control any electronic equipment in homes and industries. Moreover, you can read a data from any sensor and analyse it graphically from anywhere in the world. Here, we can read temperature and humidity data from sensor and upload it to a Thing Speak cloud using Arduino Uno and ESP8266-01 module.

Arduino MKR WiFi 1010 board, it fetch a data of humidity and temperature from DHT22 sensor and Process it and give it to a ESP8266 Module.ESP8266 is a WiFi module, it is one of the leading platform for Internet of Things. It can transfer a data to IOT cloud and another smart feature is that To on the heater using the app when moisture is high and humidity is low and voice recognition system for visually impaired in our integrated app , all these features are connected to a app which make it easy for the users to monitor their greenhouse whenever they want and wherever they

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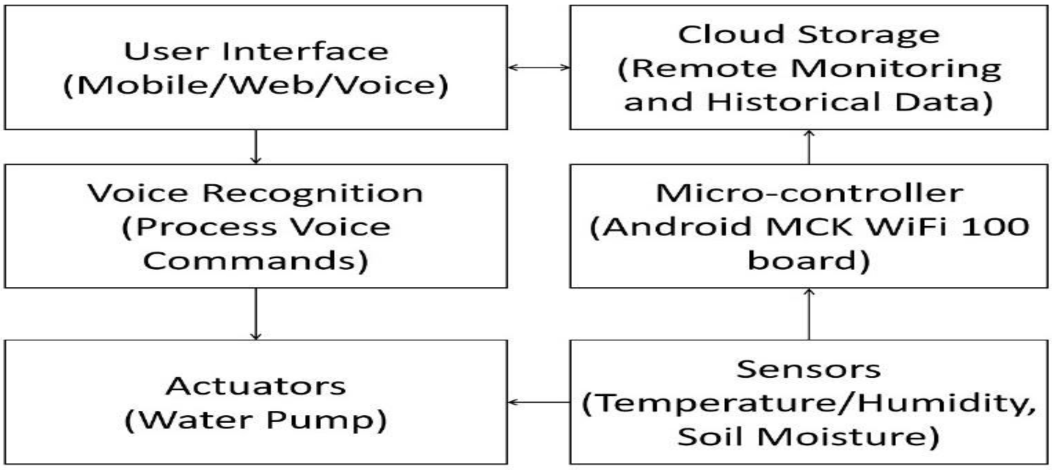

Fig.1 Block Diagram

II. OVERVIEW

This IOT Based Mini Greenhouse is focusing on controlling irrigation and temperature surrounding of Greenhouse. This system attached with the mini greenhouse, where the soil moisture sensor will plant in the soil, while DHT22 sensor (Humidity and temperature sensor) place on the ground as it would sense the surrounding. During user are away from greenhouse, they would be alerted the moisture, temperature and humidity readings with notification via Internet of Things (IoT) by using ThingSpeak.

In an IoT-based greenhouse monitoring system, voice recognition adds a hands-free, user-friendly interface for controlling and monitoring greenhouse conditions. By integrating voice commands with the Android MCK WiFi 100 board, users can effortlessly control temperature, humidity, lighting, and irrigation systems within the greenhouse. The MCK WiFi 100 provides reliable wireless connectivity to sensors and actuators, enabling real-time monitoring and control through voice commands. This setup allows farmers or greenhouse operators to manage their environment without needing manual inputs, improving efficiency, productivity, and ease of operation. Through voice recognition, automation becomes more intuitive, enhancing user experience while optimizing greenhouse performance.

In this project, Proteus will be connected to ThingSpeak and ThingSpeak will send notification of temperature, humidity and moisture readings. 2 input sensor which is the capacities of soil moisture sensor. DHT22 sensor will be used in this project that will control by Arduino IDE. After cloud receive the data of the readings, it will notify the user by sending notification through smartphone. Then, once the temperature and humidity reach the limitation, the fan will automatically start working until reach ideal temperature. At the same time, if the moisture reading are too low, the DC motor that act as sprinkler, would start working until the moisture sensor sense the ideal reading.Refer Fig 2 and Fig 5 for the real time statistics.

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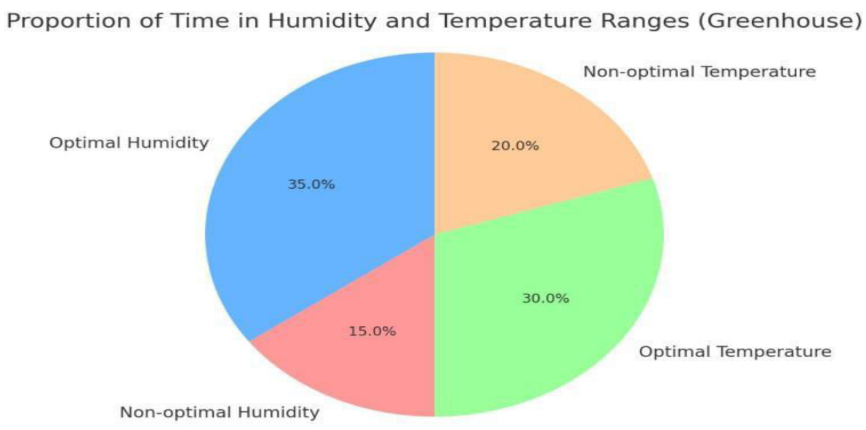

Fig.2: Real-Time data for proportion of time in humidity and temperature ranges in greenhouse

III. COMPONENTS

HARDWARE:

1.DHT22 - It has outshines the DHT11 in every aspect from temperature range, temperature accuracy, humidity range to humidity accuracy
2.Arduino MKR WiFi 1010 board - It comes with a variety of sensors and can be used with an IoT carrier to activate relays and a water pump. So, we can also use an Arduino Uno board for greenhouse monitoring and control. The Uno is the most popular Arduino board and is a good choice for beginners

SOFTWARE SPECIFICATION

1. Python- Python Libraries for Voice Recognition;Use Python libraries like speech_recognition or Google Cloud Speech API to process the voice commands.
2. MQTT Protocol: Use MQTT to communicate between your voice recognition system and IoT sensors in real-time.
3. Cloud Storage: If you use

EXISTING SYSTEM

The idea of the existing system is that they discusses the development of an IoT-based Smart Greenhouse model aimed at improving agricultural practices by automating key processes. The system uses modern technology, including sensors, GSM modules, and microcontrollers, to manage irrigation, temperature, humidity, and lighting, ensuring optimal growth conditions for plants. It employs drip irrigation to conserve water, while LED lights provide necessary wavelengths for photosynthesis during low-light conditions. The greenhouse is also equipped with bee-hive monitoring for honey production and connects directly to e-commerce platforms, bypassing middlemen. Ultrasonic sensors monitor water levels, and the entire system can be controlled remotely via SMS. The smart greenhouse improves crop yield, reduces pesticide usage, and enhances overall farming efficiency, helping farmers produce organic crops and directly reach consumers.In this a primary disadvantage of an IoT-based smart greenhouse model is its “dependency on technology”, which can lead to operational challenges during technical failures or network outages.

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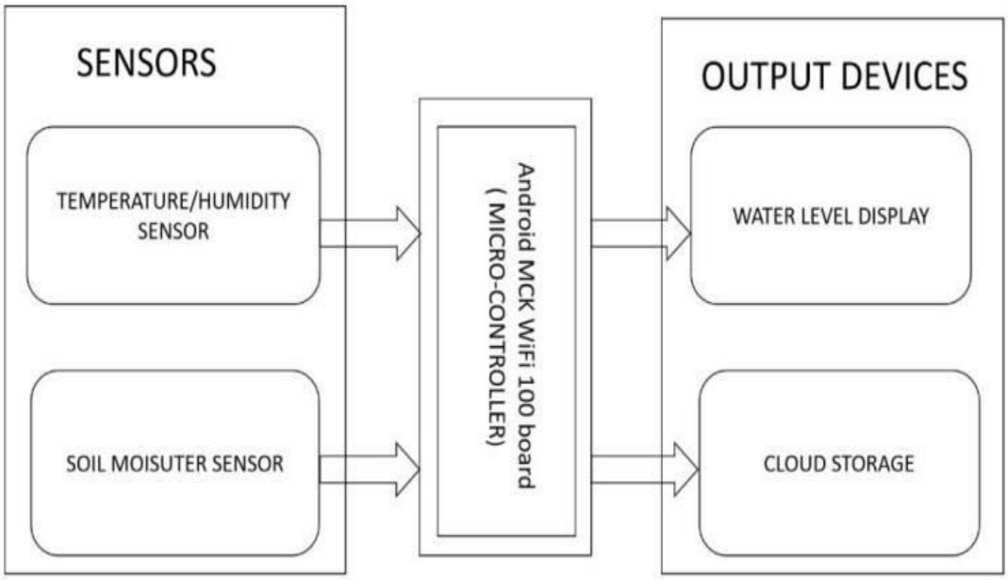

Fig.3 Functional Requirements

IV. PROPOSED SYSTEM

A. Abbreviations and Acronyms:
1.DHT22 - Humidity and temperature sensor
2.ESP8266 - WiFi module
3.Arduino MKR WiFi 1010 board

B. Objective:
1. Automate key processes such as irrigation, temperature, humidity, and lighting control to optimize growth conditions and improve crop yield.
2. Enable remote monitoring and control through mobile or web applications, providing farmers with real-time data for informed decision-making.
3. Promote sustainability by conserving resources, reducing pesticide usage, and connecting farmers directly with consumers for organic produce sales.
4. Enhance user experience with a hands-free voice recognition interface, empowering farmers to manage their greenhouses more efficiently.

C. Methodology: The methodology for developing an IoT-based greenhouse monitoring system enhanced with voice recognition technology begins with a requirement analysis to identify specific needs in greenhouse management, including parameters like temperature, humidity, and CO2 levels. Next, the system's architecture is designed, selecting appropriate hardware components such as sensors (DHT22 for temperature and humidity, CO2 sensors), actuators (water pumps, ventilation fans), a micro-controller (Arduino Uno or MKR WiFi 1010), and a WiFi module (ESP8266-01).

Integration follows, where sensors and actuators are connected to the micro-controller on a breadboard or PCB, ensuring effective data transmission. Software development involves creating firmware for the micro-controller to read

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sensor data and control actuators based on predefined conditions, as well as implementing communication protocols for data transmission to an IoT platform like ThingSpeak.

Voice recognition implementation is also programmed to enable the system to recognize specific commands for greenhouse management. Data processing algorithms are established for analyzing collected data, and historical data is stored in the cloud for visualization and further analysis.

After extensive testing and validation in a controlled environment to ensure functionality, the system is deployed in a real greenhouse setting, with ongoing monitoring to make necessary adjustments based on performance and user feedback. Finally, maintenance and updates are provided to support system longevity, incorporating user feedback for future improvements. This structured approach facilitates the effective design, implementation, and management of an intelligent greenhouse monitoring system.

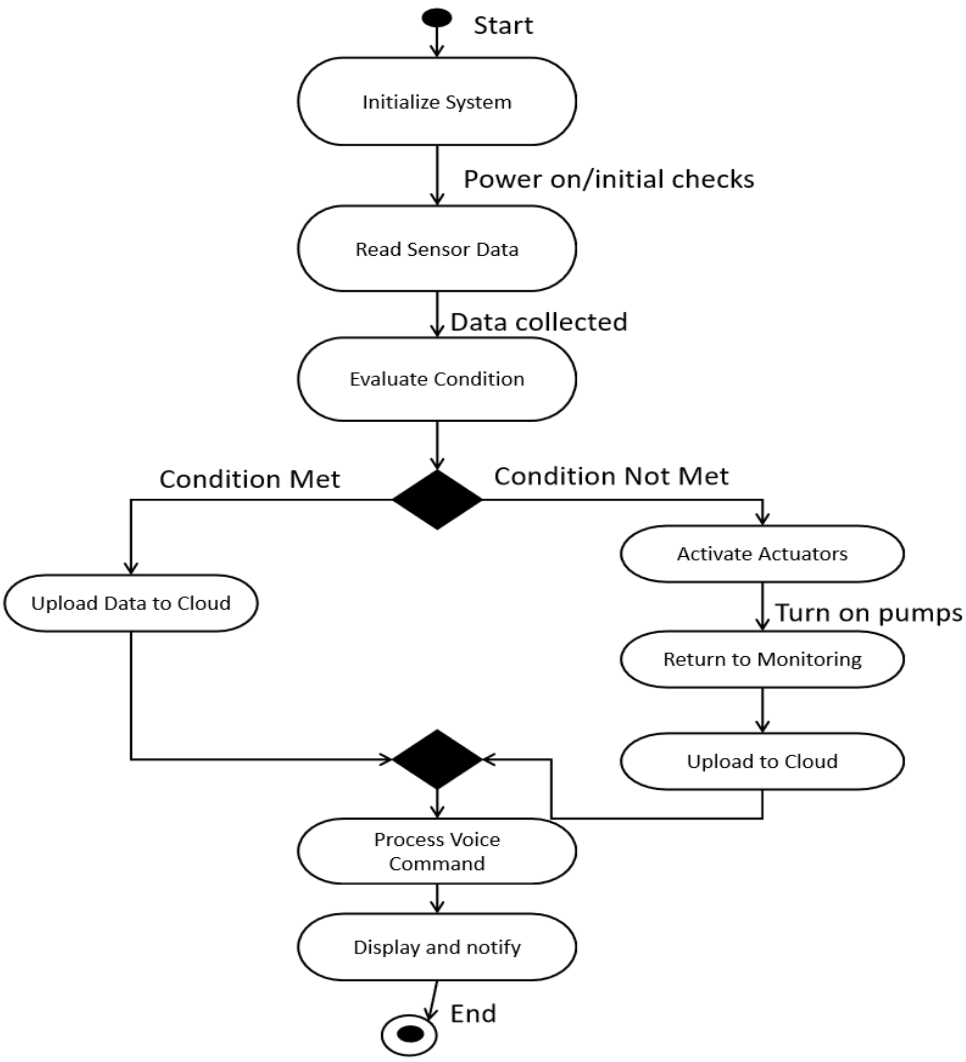

Fig 4: Application diagram

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V.IMPLEMENTATION OF PROJECT

This user friendly project is designed to monitor and control IoT based greenhouse monitoring system using IoTand arduino uno . three sensors are used to monitor temperature , humidity , heat . in this project we are using sensors to detect humidity and temperature,using internet of things (iot), we can control any electronic equipment in homes and industries. moreover, you can read a data from any sensor and analyse it graphically from anywhere in the world. here, we can read temperature and humidity data from DHT22 sensor and upload it to a thingspeak cloud using Arduino MKR WiFi 1010 board and esp8266-01 module.

Arduino MKR WiFi 1010 board is mcu, it fetch a data of humidity and temperature from DHT22 sensor and process it and give it to a esp8266 module.esp8266 is a wifi module, it is one of the leading platform for internet of things. it can transfer a data to iot cloud and heat sensor is used to on the heater when the mositure is low and humidity is high and all these features are integrated with an app which make it easy for the users to monitor and use the features of the greenhouse whenever they are and the app also has voice regocition system for visually impaired system which make it more comfortable and easier for the users to use it and this proposed system has more advantages then compared to the actually existing system.

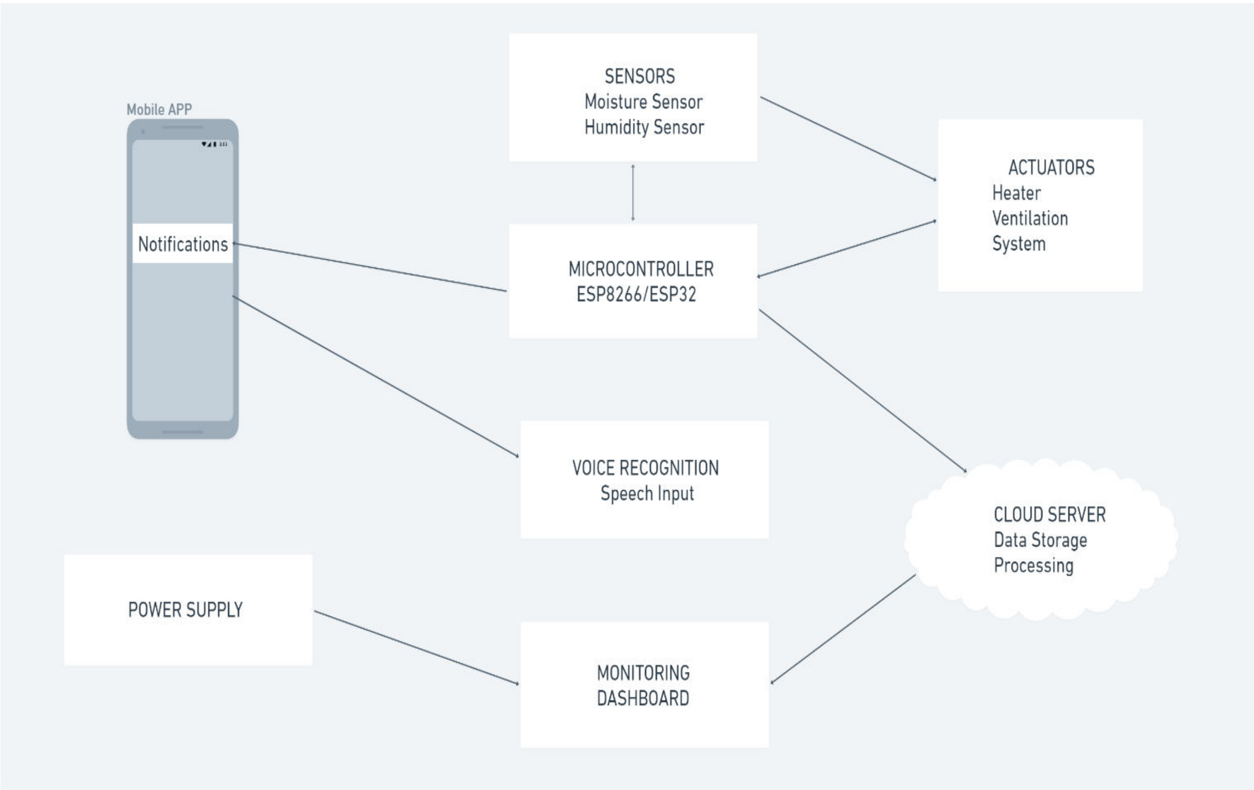

Fig 5: Flow chart of proposed solution

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REAL-TIME STATISTICAL DATA:

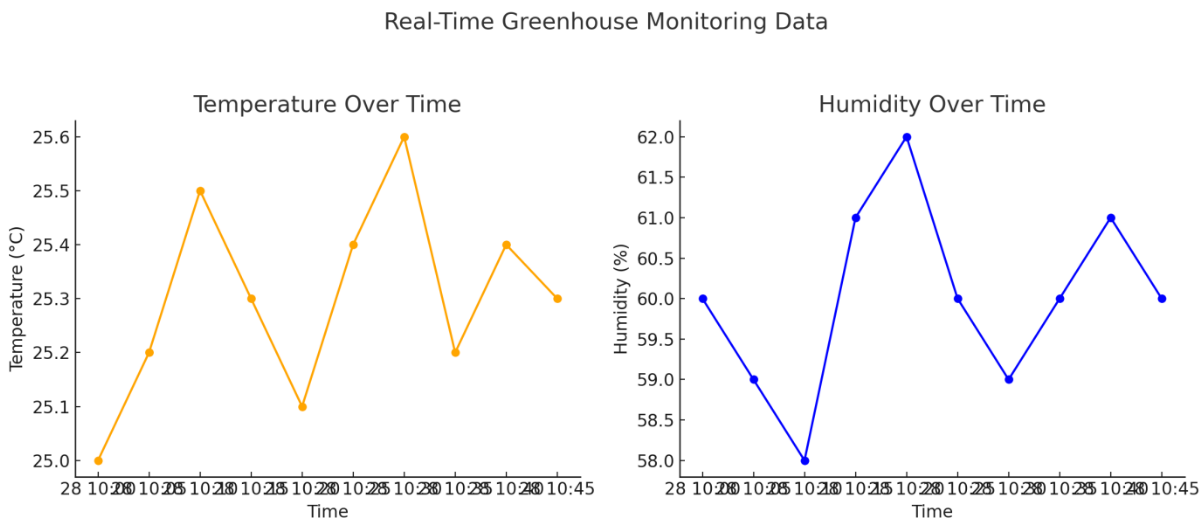

Fig 6: Real-time Greenhouse Monitoring Data

The integration of technology in agriculture has transformed traditional farming practices, especially in greenhouse management. Monitoring key environmental parameters like temperature and humidity is vital for optimizing plant growth and ensuring high crop yields. Each plant species requires specific climatic conditions, and any deviations from these can adversely affect their health and productivity. By maintaining optimal temperature ranges—typically between 20°C to 25°C—and moderate humidity levels of 50% to 70%, growers can significantly enhance growth rates and crop quality.

Furthermore, effective temperature and humidity control plays a critical role in disease prevention. High humidity can lead to fungal diseases, while low humidity may cause plant stress and dehydration. By actively monitoring these factors, greenhouse managers can implement timely interventions, such as adjusting irrigation and ventilation systems. This proactive approach not only safeguards plant health but also promotes resource efficiency, allowing for optimized water and energy use throughout the process.

The real-time data visualization of temperature and humidity provides valuable insights for greenhouse management. By analyzing trends over time, managers can quickly identify anomalies and make informed decisions regarding heating, cooling, and irrigation practices. This intelligent monitoring system fosters an adaptive farming strategy, enhancing crop yields while promoting sustainable agricultural practices. Ultimately, integrating technology into greenhouse management allows for a more responsive approach, supporting the health and productivity of plants in an increasingly unpredictable climate.

System	Accuracy %	False Positives %	False Negatives %	Processing Time per Frame (ms)	Scalability
Manual	70 – 80	5	20	N/A	Low

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Review					
Dedicated Helmet Detection Systems	80 – 90	10	15	50	Moderate
Proposed System	90 - 95	8	12	20	High

Tab.1 Comparative Analysis for System Scalability

VI. ADVANTAGE

1.Enhances crop yields by maintaining optimal growing conditions.
2.Helps prevent diseases by detecting conditions that promote fungal growth.
3.Improves resource efficiency by optimizing water and energy use.
4. Enables better decision-making through real-time data visualization.
5.Reduces the need for manual monitoring, saving labor costs.
6.Allows for remote monitoring, providing flexibility for timely interventions.
7.Contributes to more sustainable agricultural practices by optimizing resource use.
8.Fosters a more efficient approach to greenhouse management, benefiting farmers and consumers.

VII. FUTURE WORK

- Advanced technologies like artificial intelligence and machine learning will be integrated to analyze data and optimize growing conditions, allowing for more precise environmental control.
- Automation will enhance greenhouse operations through robotics for tasks such as planting and harvesting, reducing labor costs while improving efficiency.
- Voice recognition technology will provide a hands-free interface for users, enabling them to interact with monitoring systems and issue commands for adjustments to temperature, humidity, and irrigation without manual input.
- Data-driven decision-making will become more prevalent, with enhanced analytics tools and voice-activated commands providing deeper insights into plant health and environmental conditions, facilitating timely interventions.

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