IoT based Agriculture Support System

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1 Abstract

This project presents an innovative IoT-based agricultural support system tailored explicitly for greenhouse environments. With a growing emphasis on sustainable and efficient agricultural practices, the integration of IoT technologies in greenhouse farming stands as a significant advancement. The system combines a network of sensors, including the DHT 11 for temperature and humidity monitoring and the resistive soil moisture sensor for precise irrigation management, enabling real-time data collection crucial for optimizing crop growth conditions.

The study encompasses a comprehensive literature survey, drawing insights from multiple IEEE research papers and culminating in an in-depth analysis of the Tanjian University, China's publication on IoT-enabled greenhouse systems. The integration of Thingsboard software further fortifies the system, allowing remote monitoring, control, and data visualization. This user-friendly interface empowers farmers to make informed decisions, remotely manage environmental factors, and ensure optimal conditions for plant growth.

By amalgamating IoT principles with greenhouse agriculture, this system not only enhances crop yield and quality but also promotes resource efficiency and sustainability. The findings underscore the significance of real-time monitoring and automated control mechanisms in modern agricultural practices. The implementation of this IoT-based system holds promise for revolutionizing greenhouse farming, paving the way for smarter, more efficient, and sustainable agricultural practices.

The outcomes of this research highlight the potential for widespread adoption of IoT-based systems in agriculture, offering a scalable and adaptable solution to address the challenges faced by modern farmers. The system's ability to optimize resource utilization, minimize manual intervention, and maximize crop yield signifies a crucial step towards a more resilient and productive agricultural future.

2 Executive Summary

This IoT-based system presents a potential shift in modern agriculture, offering a scalable and adaptable solution for optimizing resource usage, improving crop quality, and maximizing yield. By enabling remote monitoring and control, the system introduces efficiencies that could revolutionize traditional farming practices.

The findings highlight the system's potential to reshape agricultural methods, providing farmers with the tools for more informed decision-making, remote environmental management, and a pathway to more sustainable and efficient farming practices.

3 Literature survey

The development of IoT-based systems in agriculture has garnered significant attention in recent years. To grasp the breadth of research in this domain, our survey encompassed a comprehensive review of 20 research papers and scholarly articles sourced from reputable platforms such as academia, IEEE, and Google Scholar. Following rigorous scrutiny, four papers emerged as pivotal contributions in the realm of IoT-enabled greenhouse systems, originating from Tanjian University, Tokyo University of Agriculture, Gangadhar Meher University, and Tata Consultancy Services.

Among the selected papers, the research conducted by Tanjian University stood out for its cost-effectiveness and practical feasibility, rendering it an ideal candidate for replication and implementation. This specific solution not only demonstrated robustness in its technological design but also presented an economically viable approach, making it accessible to a wide spectrum of greenhouse farms.

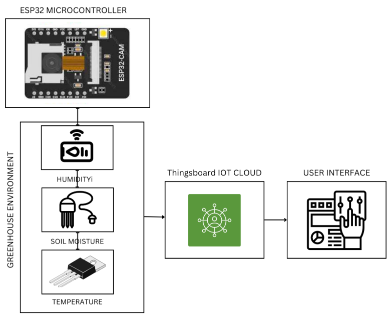

Figure 1: Block Diagram

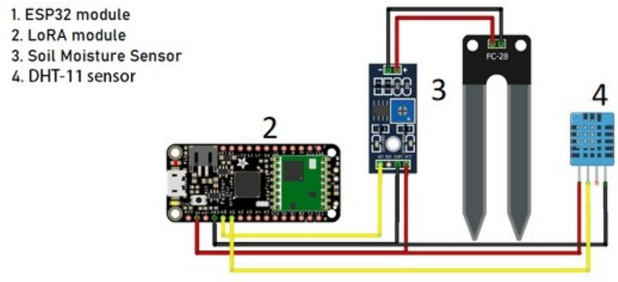

Figure 2: simulation and connection

The Tanjian University research paper elucidated the seamless integration of IoT technologies into greenhouse environments, emphasizing real-time monitoring and automated control mechanisms. Their approach showcased a pragmatic blend of sensor networks and data-driven methodologies, providing an efficient means of enhancing crop cultivation practices.[1]

The system's cost-effectiveness stemmed from its streamlined design, leveraging readily available components and protocols without compromising functionality. This cost-conscious approach aligns with the needs of various greenhouse farms, ensuring affordability without compromising the system's efficacy.

Moreover, the paper's emphasis on feasibility and scalability resonated with the challenges faced by the agricultural sector. The outlined solution showcased adaptability, catering to diverse greenhouse settings while maintaining a user-friendly interface, a crucial aspect for widespread adoption and seamless integration into existing farming practices.

The replication of the Tanjian University solution holds promise not only in its economic viability but also in its potential to introduce transformative changes in greenhouse agriculture. By capitalizing on this cost-effective yet robust approach, the envisioned system aims to bridge the gap between technological innovation and practical implementation, propelling agricultural practices towards sustainability and efficiency.

Through our comprehensive literature survey, the Tanjian University research paper emerged as the optimal choice, aligning with our objectives of affordability, feasibility, and scalability. Its potential to revolutionize greenhouse farming practices makes it a compelling model for our study's replication and implementation.

4 Components that were mentioned and its equivalent

The Tanjian university fully funded this project as it was cost efficient. They ordered the sensors from Netatmo [5]. But here we are planning to buy the equivalent components from the market whose cost are very affordable yet within the required range

4.1 Hardware

1. Microcontroller:
   ESP32 board.
   This will serve as the central processing unit for data collection, processing, and connectivity.
   Power supply for the microcontroller

2. Humidity Sensor:
   A humidity sensor DHT11 to measure greenhouse humidity levels.

3. Soil Moisture Sensor:
   A soil moisture sensor (resistive) to measure the moisture content in the soil.

4. Additional Components:
   Wiring and Breadboard To connect and prototype the components effectively.

4.2 Software

1. IoT cloud interface (Thingsboard)

2. Programming environment (Arduino IDE for ESP32)

3. Simulation software (TinkerCAD and proteus)

5 Components Description

5.1 DHT11

The DHT11 sensor stands as a widely employed and cost-effective digital temperature and humidity sensor utilized across a spectrum of applications, finding its niche in greenhouse monitoring systems, weather stations, and various home automation projects. Composed of distinct components, namely the humidity sensor, temperature sensor, and signal processing module, this sensor operates on the principles of capacitive humidity sensing and thermistor-based temperature measurement. The humidity sensor relies on a moisture-sensitive material, affecting its capacitance in response to changes in environmental moisture levels. Concurrently, the embedded thermistor gauges ambient temperature by altering its resistance with fluctuations in the surrounding temperature. Acting as a cohesive unit, the sensor's signal processing module seamlessly converts the analog signals obtained from both sensors into a digital output signal. Facilitating communication through a single-wire protocol, the sensor interacts with a microcontroller to convey a 40-bit data stream encompassing integral and decimal values for humidity and temperature, alongside a parity check for data integrity verification.

Despite its popularity, the DHT11 sensor exhibits certain operational considerations. While it provides reasonable accuracy in its measurements, it operates within a confined temperature range of 0-50°C and a humidity range of 20-80 percent. Moreover, its response time typically hovers around 2 seconds, signifying a moderate speed in delivering updated readings. Despite these limitations, its affordability, simplicity, and ease of integration make it an appealing choice for a myriad of applications where precise measurements are not of paramount importance. For instance, it serves as an ideal component in projects that require fundamental environmental monitoring capabilities but do not necessitate the precision afforded by more sophisticated sensors.

The utilization of the DHT11 sensor extends to various domains due to its versatile nature. It finds resonance particularly in the realm of greenhouse monitoring systems where its cost-effectiveness aligns with the broader aim of implementing affordable yet efficient technologies. Its application in greenhouse environments is rooted in the need for consistent monitoring of temperature and humidity, critical factors influencing plant growth and health. Within these settings, the sensor serves as a fundamental tool in ensuring that the environmental conditions remain conducive to optimal plant development,

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

Figure 3: DHT11 Specifications

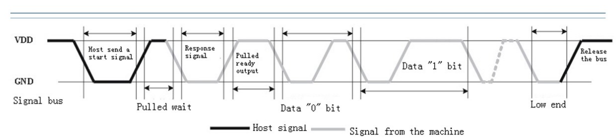

Figure 4: DHT11 Timing Diagram

thereby contributing to increased agricultural productivity.

In conclusion, the DHT11 sensor's affordability, reasonable accuracy, and ease of integration render it a valuable asset in applications where cost efficiency and basic environmental monitoring capabilities take precedence over precision. Its adoption in greenhouse monitoring systems underscores its significance in fostering efficient and cost-effective agricultural practices, providing a foundational element for the sustenance and growth of crops while catering to the technological and economic constraints faced in such environments.

5.2 Soil Moisture Sensor

The resistive soil moisture sensor stands as a fundamental component in agricultural applications, specifically designed to gauge soil moisture levels crucial for effective irrigation management. Comprising conductive probes that measure soil moisture content based on changes in resistance, this sensor operates on the principle that soil's electrical conductivity varies with its moisture level. When submerged in soil, the sensor's probes detect the moisture present, leading to alterations in resistance, which are then translated into measurable values. This resistive type sensor

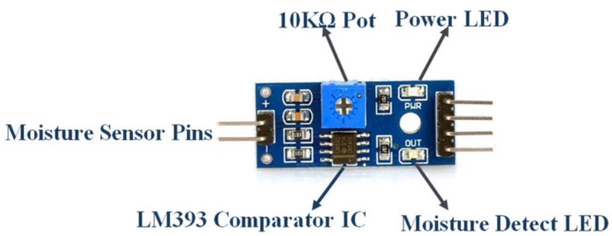

Figure 5: Soil Moisture module Diagram

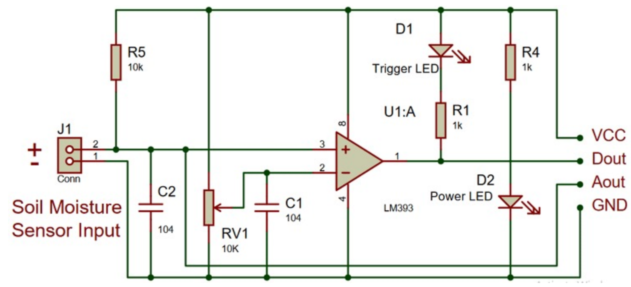

Figure 6: Soil Moisture module Diagram

provides a cost-effective solution for monitoring soil moisture, offering simplicity and ease of integration into various agricultural systems. However, similar to other resistive sensors, its accuracy might be influenced by factors like soil composition and salinity, requiring calibration for precise measurements. Despite these considerations, its affordability and basic functionality make it a practical choice for irrigation management systems, allowing farmers to optimize watering schedules and ensure adequate moisture levels for optimal plant growth and yield.

Soil Moisture Sensor Module Features and Specifications:
Operating Voltage: 3.3V to 5V DC
Operating Current: 15mA
Output Digital - 0V to 5V, Adjustable trigger level from preset
Output Analog - 0V to 5V based on infrared radiation from fire flame falling on the sensor
LEDs indicating output and power
PCB Size: 3.2cm x 1.4cm
LM393 based design

Connecting the typical application circuit shown above the microprocessor and DHT11, DATA pull-up and microprocessor I/O port. 1. A typical application circuit recommended cable length shorter than 20 meters with a 5.1K pull-up resistor when greater than 20 meters when the pull-up resistor to reduce the actual situation. 2. When using a 3.3V voltage supply cable length must not be greater than 100cm. Otherwise it will lead to lack of line drop sensor supply, causing measurement bias. 3. Temperature and humidity values are read out every last measurement result, want to get real-time data, to be read twice in a row, but not recommended repeatedly read sensors, each sensor reading interval of more than 5 seconds to obtain accurate data.

Moisture sensor module consists of four pins i.e. VCC, GND, DO, AO. Digital out pin is connected to the output pin of LM393 comparator IC while the analog pin is connected to Moisture sensor. The internal Circuit diagram of the Moisture sensor module is given below.

Using a Moisture sensor module with a microcontroller is very easy. Connect the Analog/Digital Output pin of the module to the Analog/Digital pin of Microcontroller. Connect VCC and GND pins to 5V and GND pins of Microcontroller. After that insert the probe inside the soil. When there is more water presented in the soil, it will conduct more electricity that means resistance will be low and the moisture level will be high.

Resistive soil moisture sensors find extensive application in agricultural contexts, primarily in precision farming and greenhouse environments. Their integration into irrigation systems enables real-time monitoring of soil moisture levels, providing crucial data for informed decision-making in watering practices. Within greenhouse settings, these sensors play a pivotal role in maintaining ideal soil moisture conditions essential for plant growth. While not as precise as some other advanced sensors, the resistive soil moisture sensor serves as a reliable tool for cost-conscious farmers seeking efficient irrigation strategies. Its significance lies in its ability to contribute to sustainable agriculture by promoting water conservation through optimized irrigation practices, thus enhancing crop productivity while minimizing water usage.

6 IoT implementation

The implementation of IoT technology using the Thingsboard platform stands as a cornerstone in the development of the agricultural support system for greenhouses. Thingsboard, a user-friendly IoT platform, facilitates seamless connectivity between sensors, microcontrollers, and mobile devices, offering a versatile interface for data visualization, remote monitoring, and control. Through its intuitive app-based framework, Thingsboard empowers farmers or users to remotely access real-time data collected by sensors, granting insights into crucial environmental parameters such as temperature, humidity, and soil moisture levels. Leveraging Thingsboard's customizable widgets and dashboard functionalities, users can efficiently monitor the greenhouse conditions, set thresholds, and receive alerts or notifications, enabling prompt and informed decision-making. This IoT implementation using Thingsboard bridges the gap between physical sensors and actionable insights, providing an accessible and practical means to manage and optimize the greenhouse environment for improved crop cultivation. While ensuring ease of use and remote accessibility, Thingsboard's integration ensures the system's adaptability and scalability, catering to diverse greenhouse setups and user preferences, thereby revolutionizing traditional agricultural practices by introducing a user-friendly and data-driven approach to greenhouse farming management.

7 Microcontroller

We have already mentioned everything about the ESP32 microcontroller in the abstract that we have submitted. The incorporation of ESP32 microcontroller modules within the IoT-based agricultural support system for greenhouses stands as a pivotal technological integration. The ESP32, renowned for its versatility and capabilities, serves as the central processing unit, facilitating seamless connectivity and data transmission between sensors and the Thingsboard platform. With its robust processing power and built-in Wi-Fi and Bluetooth capabilities, the ESP32 acts as a reliable hub, collecting data from various sensors, including temperature, humidity, and soil moisture sensors. This microcontroller efficiently communicates sensor data to the Thingsboard cloud, enabling remote access and control via the Thingsboard mobile application or web interface. Its dual-core architecture and support for multiple communication protocols ensure rapid data processing and transmission, ensuring real-time monitoring and prompt responsiveness to user commands or automated control actions. The ESP32's integration into the IoT ecosystem not only enhances the system's efficiency but also contributes to its adaptability, making it a cornerstone for the creation of a smart and responsive agricultural environment. Its versatility, coupled with Thingsboard's user-friendly interface, presents an amalgamation that revolutionizes greenhouse farming practices, offering a scalable, efficient, and data-centric approach to managing and optimizing crop cultivation.

8 Appendix

A summary on "Design and Implementation of the Span Greenhouse Agriculture Internet of Things System": The existing application system of agricultural production technology was a single service mode; and it has a high cost of application, poor in market information communicating, and weak in security monitoring. The applications are slim in view of life ontology information awareness, and crop growth process modeling of crop pests and diseases diagnosis. We set environmental monitoring sensors in each of the selected Greenhouse premises, including soil temperature, soil moisture, air temperature, air humidity, CO_2, light intensity, etc. At the same time, we set outdoor meteorological and video information monitoring stations in each selected internal deployment of the greenhouse, mainly including outdoor air temperature, air humidity, wind speed, wind direction, rainfall, and video data six parameters. At the same time, we set a sticker camera in the selected inside greenhouse of the deployment for the production managers and industry executives to get a remote view of greenhouse production, especially monitoring greenhouse production situation in severe weather timely. The main function of the intelligent control system comprises variable frequency pump control, constant pressure water supply control, integrated intelligent greenhouse control, pest warning control, automatic control of irrigation, fertilization of automatic control and automatic spraying control. The facility environmental factors can be collected through an information collection system in real-time (frequency of once every 10 min), analyze the various growth environmental data collected for statistical data preprocessing and pretreatment, and process the integrated data through a model of pests and diseases.

9 Code

```
#include <WiFi.h>
#include <Wire.h>
#include <HTTPClient.h>

#define DHT_PIN 4
#define sensor_pin 33

const char *ssid = "Galaxy";
const char *password = "plyb7569";
const char *thingsboardServer = "demo.thingsboard.io";
const char *deviceToken = "XbGZV4mecdNQjkpLi1PS";

void setup() {
  Serial.begin(9600);
  Wire.begin();
  // Connect to Wi-Fi
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }
  Serial.println("Connected to WiFi");
}

void loop() {
  int humidity, temperature;
  int moisture_percentage;
  float moisture_analog;
  float moisture;

  if (readDHT11Data(DHT_PIN, &humidity, &temperature)) {
    Serial.print("Humidity: ");
    Serial.print(humidity);
    Serial.print("%, Temperature: ");
    Serial.print(temperature);
    Serial.println("°C");
  }
  else {
    Serial.println("Failed to read data from DHT11 sensor");
  }

  moisture = analogRead(sensor_pin);
  moisture_analog = moisture/4095;
  moisture_percentage = 100 - (100*moisture_analog);

  Serial.print("Soil Moisture(in Percentage) = ");
  Serial.print(moisture_percentage);
  Serial.println("%");

  sendDataToThingsBoard(moisture_percentage, humidity, temperature);
```

```
  delay(2000);
}

bool readDHT11Data(int pin, int *humidity, int *temperature) {

  int data[5] = {0, 0, 0, 0, 0};


  pinMode(pin, OUTPUT);
  digitalWrite(pin, LOW);
  delay(18);
  digitalWrite(pin, HIGH);
  delayMicroseconds(40);
  pinMode(pin, INPUT);

  unsigned long timeout = micros() + 80;
  while (digitalRead(pin) == LOW) {
    if (micros() > timeout) {
      return false;
    }
  }

  timeout = micros() + 80;
  while (digitalRead(pin) == HIGH) {
    if (micros() > timeout) {
      return false;
    }
  }

  for (int i = 0; i < 40; i++) {
    timeout = micros() + 80;
    while (digitalRead(pin) == LOW) {
      if (micros() > timeout) {
        return false;
      }
    }

    unsigned long startTime = micros();
    timeout = micros() + 80;
    while (digitalRead(pin) == HIGH) {
      if (micros() > timeout) {
        return false;
      }
    }

    unsigned long duration = micros() - startTime;

    data[i / 8] <<= 1;
    if (duration > 40) {
      data[i / 8] |= 1;
    }
  }

  if (data[4] == ((data[0] + data[1] + data[2] + data[3]) & 0xFF)) {
```

```
    *humidity = data[0];
    *temperature = data[2];
    return true;
  }

  else {
    return false;
  }
}

void sendDataToThingsBoard(float moisture_percentage, int humidity, int temperature) {
  HTTPClient http;

  String url = "http://" + String(thingsboardServer) + "/api/v1/" +
  String(deviceToken) + "/telemetry";

  String payload = "{\"moisture\":" +
  String(moisture_percentage) + ", \"humidity\":" + String(humidity) + ",
  \"temperature\":" + String(temperature) + "}";

  http.begin(url);
  http.addHeader("Content-Type", "application/json");
  int httpResponseCode = http.POST(payload);

  if (httpResponseCode > 0) {
    Serial.print("HTTP Response code: ");
    Serial.println(httpResponseCode);
  }
  else {
    Serial.print("HTTP POST request failed: ");
    Serial.println(httpResponseCode);
  }

  http.end();
}
```

References

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