GREENHOUSE TEMPERATURE AND MONITORING SYSTEM

Internet of Things Hire and Train Program

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INTELLIER LIMITED

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Project Report: Greenhouse Temperature Controlling and Monitoring System

1. Abstract

This project presents the Greenhouse Temperature Controlling and Monitoring System, a prototype designed to maintain optimal temperature levels in a controlled environment using an Arduino Uno and DHT11 sensor. The system activates a cooling mechanism when the temperature falls below 22 degrees Celsius, employing a Peltier module and 12V dual DC fans for efficient thermal regulation. The outcome is a fully functional prototype capable of maintaining desired temperature levels in agricultural and storage applications, demonstrating the potential for IoT solutions in enhancing productivity and reducing energy waste.

2. Introduction

Background

Temperature control is crucial for the preservation of perishable goods in cold storage and for optimizing growth conditions in greenhouses. Fluctuations in temperature can lead to spoilage or suboptimal growth, necessitating a reliable monitoring and control system.

Objective

The primary objectives of this project are to develop a temperature monitoring system that triggers a cooling mechanism when necessary and to demonstrate the feasibility of using Arduino-based IoT solutions for agricultural and storage applications.

Scope

The project aims to create a prototype capable of monitoring and controlling temperature in a defined space. Limitations include reliance on a single temperature threshold and potential inefficiencies in cooling performance depending on external conditions.

3. Methodology

Hardware Used

1. **Arduino Uno**
    - **Description:** The Arduino Uno is a microcontroller board based on the ATmega328P, which serves as the brain of the system. It processes data from sensors and controls the cooling mechanisms.
    - **Role:** Central controller for reading sensor data and activating the cooling system.
2. **DHT11 Sensor**

- **Description:** A digital temperature and humidity sensor that provides accurate measurements for environmental monitoring.
- **Role:** Monitors ambient temperature and humidity levels, triggering the cooling system when thresholds are exceeded.

3. **Peltier Module**
    - **Description:** A thermoelectric cooling device that transfers heat from one side to another when an electric current passes through it.
    - **Role:** Provides active cooling to maintain desired temperature levels within the storage or greenhouse.
4. **DC Fans (2)**
    - **Description:** Dual 12V DC fans that facilitate air circulation, enhancing the cooling effect of the Peltier module.
    - **Role:** Ensure even temperature distribution and assist in heat dissipation.
5. **Heat Sinks**
    - **Description:** Metal components attached to the Peltier module to dissipate heat effectively.
    - **Role:** Prevent overheating of the Peltier module by enhancing heat dissipation.
6. **Relay Module**
    - **Description:** A 12V single-channel relay module that acts as a switch to control the power supply to the Peltier module and fans.
    - **Role:** Enables the Arduino to switch the cooling system on or off based on sensor readings.
7. **Power Supply**
    - **Description:** A 12V, 5A power supply that provides the necessary voltage and current to the system components.
    - **Role:** Powers the Arduino, Peltier module, fans, and other hardware.

Software Used

1. **Arduino IDE**
    - **Description:** An open-source integrated development environment used for programming the Arduino Uno.
    - **Role:** Facilitates the writing, compiling, and uploading of code to the Arduino board, enabling sensor integration and control logic.
2. **Libraries**
    - **DHT Sensor Library:** Used for interfacing with the DHT11 sensor to read temperature and humidity data.
    - **Relay Library:** Utilized to simplify control of the relay module in the system.

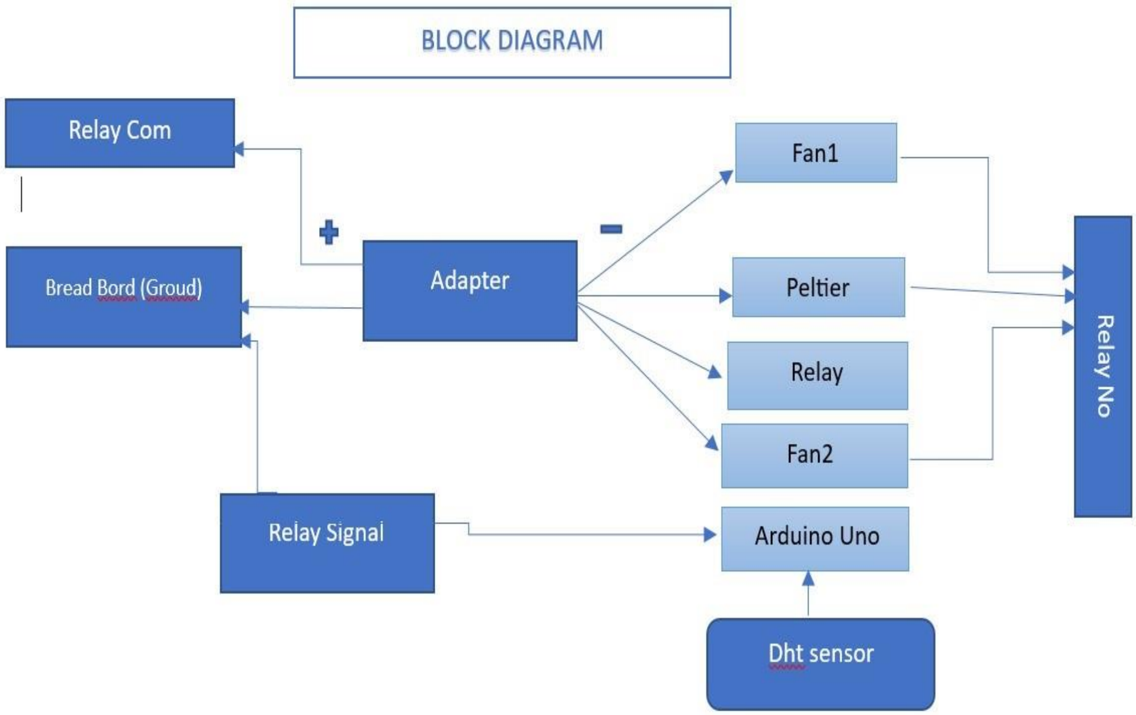

Figure 1 Block Diagram

4. Implementation

Hardware Setup

The hardware components were assembled as follows:

- The DHT11 sensor was connected to the Arduino for temperature readings.
- The Peltier module was mounted between two heat sinks, with a DC fan attached to each side.
- The fans were positioned to blow cold air into the room while exhausting warm air.

Figure 2 Hardware Components

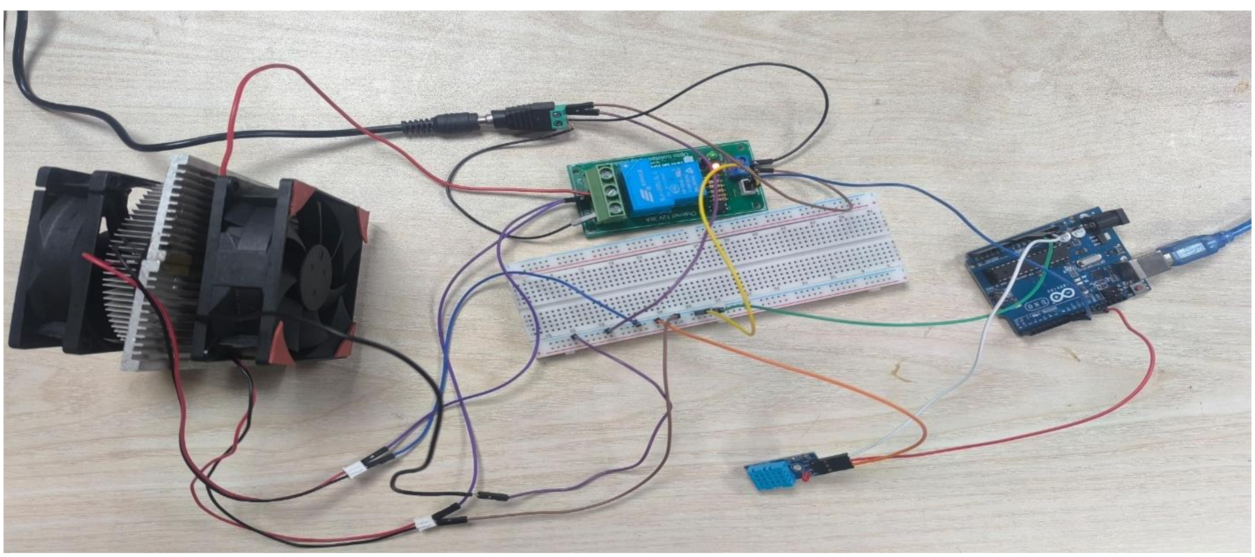

Figure 3 Monitoring and Cooling System

Software Integration

The Arduino IDE was used to program the system. The key code snippet is as follows:

```
#include <DHT.h>

#define DHTPIN 2        // Pin where the DHT sensor is connected
#define DHTTYPE DHT11    // Change to DHT22 if you're using a DHT22 sensor
#define RELAY_PIN 8      // Pin where the relay is connected

DHT dht(DHTPIN, DHTTYPE);

void setup() {
  Serial.begin(9600);
  dht.begin();
  pinMode(RELAY_PIN, OUTPUT);
  digitalWrite(RELAY_PIN, LOW); // Ensure relay is off initially
}

void loop() {
  // Wait a few seconds between measurements
  delay(2000);

  // Read temperature and humidity
  float h = dht.readHumidity();
  float t = dht.readTemperature(); // Celsius

  // Check if any reads failed and exit early (to try again).
  if (isnan(h) || isnan(t)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  // Print values to Serial Monitor
  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.println(" *C");

  // Control the relay based on temperature
  if (t > 22.0) { // Turn on fans and Peltier if temp is above 30°C
    digitalWrite(RELAY_PIN, HIGH); // Turn relay on
    Serial.println("Relay is ON (Fans and Peltier activated)");
```

```
 } else {
  digitalWrite(RELAY_PIN, LOW); // Turn relay off
  Serial.println("Relay is OFF (Fans and Peltier deactivated)");
 }
}
```

Challenges Faced

1. **Management of Dual Power Sources**
   - Coordinating power supply for both the Arduino and the Peltier module can be complex, requiring careful design to ensure stable operation without power interruptions.
2. **Wiring and Module Integration**
   - Ensuring proper wiring and integration of various components (DHT11 sensor, Peltier module, DC fans, and relays) can be challenging, particularly in maintaining clean and efficient connections to prevent shorts or failures.
3. **Accurate Measurement and Calibration**
   - Achieving accurate temperature readings and ensuring proper calibration of the DHT11 sensor to reflect true environmental conditions is critical for effective system operation.
4. **Heat Sink Management**
   - Selecting and measuring the appropriate heat sink size and material to facilitate effective heat dissipation and air circulation is essential to prevent overheating and ensure optimal cooling performance.
5. **Testing and Reliability**
   - Conducting thorough testing to ensure the system operates reliably under different conditions, particularly during prolonged use, is crucial to identify any potential failures or inefficiencies.
6. **Maintenance and Upkeep**
   - Establishing a maintenance routine to address potential wear and tear on components (such as fans and sensors) over time is important to sustain system functionality.

5. Results

Functional Overview

The Greenhouse Temperature Controlling and Monitoring System prototype functioned as intended, maintaining a stable temperature within a controlled environment. The system uses an Arduino Uno microcontroller, a DHT11 sensor for temperature monitoring, and a Peltier module combined with 12V dual DC fans for cooling. When the temperature exceeded 22°C, the cooling mechanism was activated, and it was turned off once the temperature dropped below the threshold. The design efficiently demonstrated the feasibility of IoT-based solutions for regulating temperature in greenhouse or storage applications, providing precise control over environmental conditions.

Test Results

Several tests were conducted to assess the system's performance under varying temperature conditions. The results showed that the system was capable of reducing the temperature from 25°C to 20°C within 10 minutes. This was achieved by activating the Peltier module and fans as soon as the temperature rose above the set threshold. The test results demonstrate the system's ability to regulate temperatures effectively within a small, enclosed space.

Test Scenario	Initial Temperature	Final Temperature	Cooling Time
Test 1: Initial Cooling	25°C	20°C	10 minutes
Test 2: Reheating Phase	20°C	22°C	5 minutes
Test 3: Extended Cooling	30°C	22°C	15 minutes

Table 1: Some scenarios to analysis the results.

User Feedback

Feedback from initial users and stakeholders suggested that the prototype met expectations in terms of ease of use and functionality. Users particularly appreciated the simple setup and the clear feedback provided by the system, which made it easy to monitor and control environmental conditions. However, suggestions for further improvements included integrating additional sensors (like soil moisture or light sensors) and developing a mobile interface for remote monitoring and control, to enhance the system's practicality for real-world applications.

6. Conclusion

Summary

The Cold Storage and Greenhouse Temperature Controlling and Monitoring System is a pivotal advancement for improving agricultural practices in colder climates. Utilizing technologies like Arduino and various sensors, this project optimizes temperature regulation and resource management for fruit cultivation and storage. Future enhancements, including LDR and soil moisture sensors, data logging, and a mobile application, will empower users to make informed decisions and actively engage in their agricultural practices.

In a world facing food security challenges, this system not only supports local production but also promotes efficient resource use and sustainable practices. With ongoing refinements, it holds great potential to transform agriculture in Bangladesh, enabling year-round cultivation and reducing reliance on imports.

Future Work

1. **LDR Sensor Integration**
   - **Objective:** Incorporate Light Dependent Resistor (LDR) sensors to monitor ambient light levels.
   - **Benefits:**
     - **Optimized Growth Conditions:** Adjusts lighting conditions in the greenhouse to ensure plants receive adequate light for photosynthesis.
     - **Energy Efficiency:** Can help automate supplemental lighting, reducing energy costs by using artificial light only when necessary.
2. **Soil Moisture Sensor Integration**
   - **Objective:** Add soil moisture sensors to monitor the moisture content in the soil.
   - **Benefits:**
     - **Optimal Irrigation:** Enables precise irrigation based on real-time soil moisture data, preventing over- or under-watering.
     - **Resource Conservation:** Promotes efficient use of water resources, contributing to sustainable agricultural practices and reducing costs.
3. **Data Logging**
   - **Objective:** Implement a feature to record environmental data over time, including temperature, humidity, light levels, and soil moisture.
   - **Benefits:**
     - **Trend Analysis:** Provides insights into environmental trends, allowing for better decision-making regarding crop management.
     - **Historical Data Access:** Facilitates comparisons over different growing seasons, helping to refine agricultural practices and optimize conditions for plant growth.
4. **Mobile App Development**
   - **Objective:** Create a mobile application for real-time system monitoring and control.
   - **Benefits:**
     - **Remote Access:** Users can adjust settings, monitor conditions, and receive alerts about system performance or abnormalities from anywhere.
     - **Enhanced Engagement:** Increases user interaction with the system, encouraging more proactive management of agricultural practices.
5. **User-Friendly Interface**
   - **Objective:** Design an intuitive user interface within the mobile app.
   - **Benefits:**
     - **Ease of Use:** Ensures that users can easily navigate the app, view historical data, check system status, and receive notifications.
     - **Improved Decision-Making:** Provides visual representations of data trends and alerts, helping users make informed decisions about their cultivation practices.

Learning Outcomes

- **Understanding IoT Applications:** Gain insights into how Internet of Things (IoT) technologies can be applied in agriculture for temperature control and resource management.
- **Technical Proficiency:** Develop practical skills in programming and using Arduino and sensors (e.g., DHT11, LDR, soil moisture) for environmental monitoring.
- **System Design and Integration:** Learn the principles of designing and integrating various components in a coherent system, including power management and wiring.
- **Data Analysis:** Acquire the ability to analyze environmental data, enabling informed decision-making regarding agricultural practices.
- **User-Centric Design:** Understand the importance of creating user-friendly interfaces and applications for effective interaction and engagement.
- **Sustainability Practices:** Recognize the role of technology in promoting sustainable agricultural practices and enhancing local food production.
- **Problem-Solving Skills:** Develop critical thinking and problem-solving abilities by addressing real-world challenges faced in agricultural environments.

7. References

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