CPE 301 Final Project Report
Evaporation Cooling System (Swamp Cooler)

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Introduction

This report documents the design, implementation, and testing of an Evaporation Cooling System, or swamp cooler, developed for the CPE 301 Embedded Systems Design course. The swamp cooler leverages an Arduino 2560 microcontroller and sensors to provide a cost-effective, energy-efficient cooling solution suitable for dry climates. Key features of the system include temperature and humidity monitoring, automated fan control, water level alerts, and manual vent adjustments. The following sections provide an in-depth explanation of the system design, operational states, challenges faced, and testing results.

System Design

Overview

The system operates in four states: IDLE, RUNNING, ERROR, and DISABLED. It transitions between these states based on real-time temperature, humidity, and water level inputs. The main components used in the design include:

- Arduino 2560: Central microcontroller to manage operations.
- DHT11 Sensor: Monitors temperature and humidity.
- Water Level Sensor: Detects low water levels.
- Stepper Motor: Adjusts the vent angle.
- LCD Display: Displays system status and sensor readings.
- Fan Motor: Activates to cool the environment.
- Real-Time Clock (RTC): Logs ON/OFF events with timestamps.

Circuit Schematic

Figure 1 illustrates the hardware design, showing the connections between the Arduino, sensors, LEDs, and actuators. The full schematic can be accessed at the following link: `https://app.cirkitdesigner.com/project/8e2c990f-e0d3-40e7-9011-12106a14b87e`

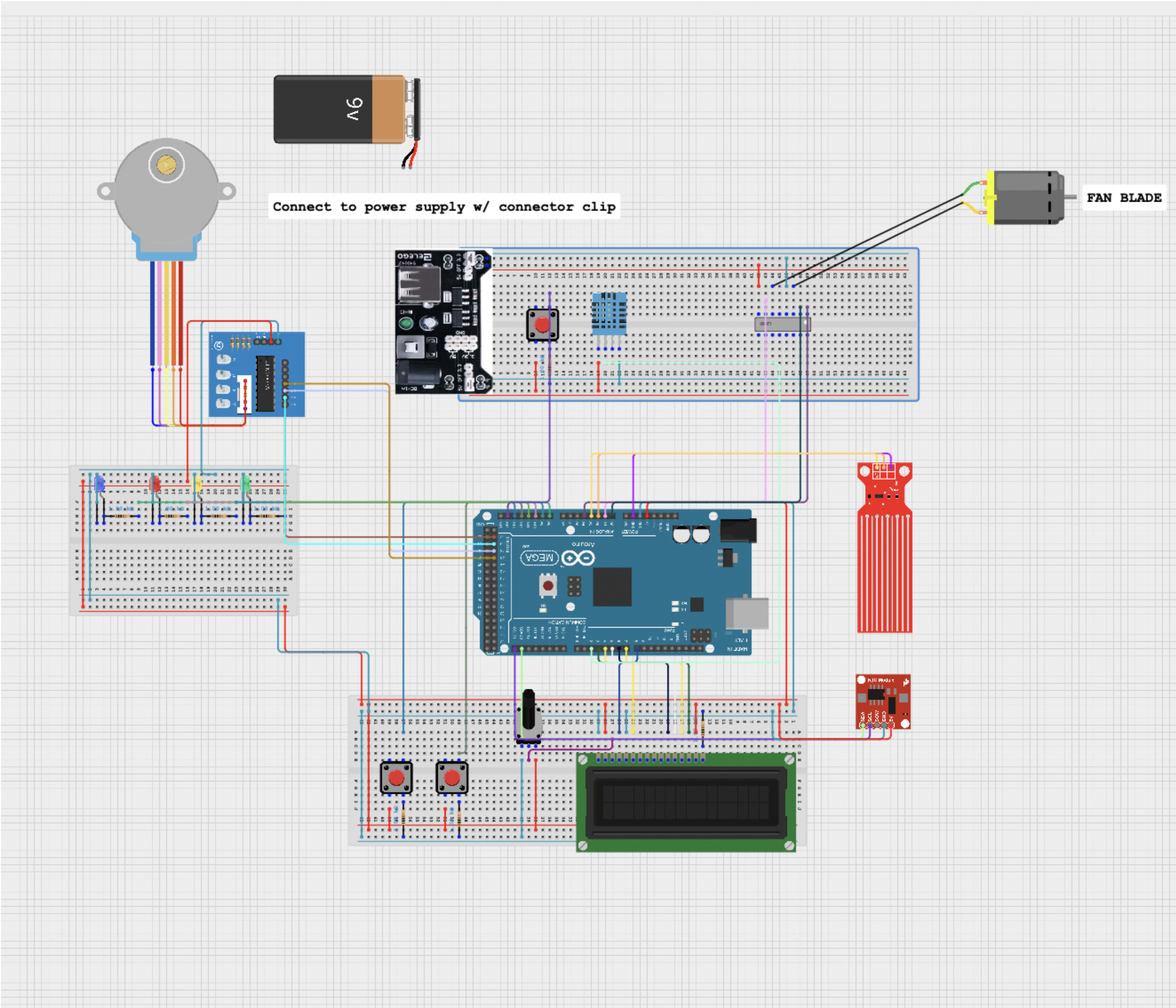

Figure 1: Circuit Schematic of the Evaporation Cooling System.

Testing and Results

Scenario 1: Normal Operation

- Observation: The system starts in IDLE, displaying temperature and humidity on the LCD.
- Action: The temperature exceeds the threshold.
- Result: The system transitions to RUNNING, the BLUE LED illuminates, the fan motor activates, and the vent adjusts.

Scenario 2: Low Water Level

- Observation: The system is in RUNNING state.
- Action: The water sensor detects low water level.
- Result: The system transitions to ERROR, the RED LED illuminates, and "Error: Water Low" is displayed on the LCD.

Scenario 3: Manual Stop

- Observation: The system is in any active state.
- Action: The stop button is pressed.
- Result: The system transitions to DISABLED, the YELLOW LED illuminates, and monitoring stops.

Challenges and Solutions

Fan Motor Stability

Problem: The fan motor occasionally delayed startup.
Solution: Verified the power connections and added delays in the code to ensure smooth operation.

Water Sensor Handling

Problem: False readings occurred when the water level sensor was removed during testing.
Solution: Improved the handling code to filter out invalid readings and ensured the sensor was properly cleaned between tests.

Conclusion

The Evaporation Cooling System successfully met the project goals by integrating multiple sensors and actuators to automate cooling operations. The system demonstrated smooth state transitions, real-time monitoring, and user control. This project showcases the practical application of embedded systems to create energy-efficient solutions.

Future Improvements

- Use a more precise temperature and humidity sensor (e.g., DHT22).
- Replace the fan motor with a more reliable model.

Deliverables

- GitHub Repository: `https://github.com/denniskwabs/CPE-301-FINAL-PROJECT.git`
- Video Demonstration: `https://youtu.be/yYOOaNy2pwI`