CSE 360

Lab Project Proposal Submission

Spring 2024

Group No: 09

Project Title: **Adaptive Environmental Management System with Integrated Temperature, Motion, and Lighting Controls**

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Introduction

To keep up with the rapidly advancing technology by incorporating it with our basic necessities, we are introducing a Home Automation System, specifically tailored for washrooms. This system eliminates the manual turning on and off of the lights and fans inside the washroom, offering us an efficient approach to save the hassle of human intervention and also energy consumption in the process.

When an individual enters the washroom, the lights inside will turn on, which in turn, will depend on if light is required to be turned on inside by sensing the intensity of daylight. The system will sense the temperature and humidity which will again decide if the fan inside the washroom should be switched on or not. An LCD screen will display the temperature according to which the user will be able to control the fan switch if they wish to. As the person exits the washroom, by detecting the direction of motion by an infrared sensor, the electric devices will be turned off automatically. This approach will ensure proper ventilation and illumination inside the washroom while a person is inside.

This innovative method of home automation ensures the functionality of the washroom by automatically turning on and off the lights and fans as well as providing efficient use of electrical energy, as opposed to the traditional way of using lights and fans. By automating lighting and fan operations based on real-time motion detection, we strive to create a more eco-friendly living environment while enhancing user comfort and convenience. This ensures a sustainable lifestyle with the help of smart home technology.

Application Area

Washroom and Toilets: Touching any sort of objects after using the toilet is too unhygienic in both public and private. Therefore, using an automated system to turn the light and fan on can reduce the spread of various viruses and bacteria.

Physically challenged patients: Patients who have to move with the help of a wheelchair or any other support can use the system without having any sort of difficulties in their day-to-day lives.

Educational Institutions: Most of the time students and teachers stay in a rush due to the heavy schedules. Therefore, classroom electronics are often forgotten to turn off and electricity wastage keeps rising. Thus, we can use this system in Educational institutions to emit the waste of electricity.

Technology and Tools Used:

- **Arduino UNO R3:** This is the main controller board for the system, responsible for processing inputs from the sensors, managing the logic of the embedded system, and controlling the output devices based on that logic.
- **PIR Sensor (HC-SR501):** A motion sensor that detects the presence of humans by sensing changes in infrared levels. When motion is detected, it sends a digital HIGH signal to the Arduino.
- **Digital Humidity & Temperature Sensor (DHT11):** This sensor will measure the ambient temperature and humidity. The data collected from the DHT11 will be used to display the temperature on the LCD and to decide when to turn the motor on or off.
- **LDR Sensor Module 5V:** A light-sensitive module that changes its resistance based on the light intensity. In this system, it is used to determine if the environment is bright enough to keep the LED turned off.
- **16x2 LCD Display with I2C Interface:** A display screen that shows 16 characters per line, with 2 lines. Using the I2C interface, it will display the current temperature, the set temperature threshold, and the fan’s current status.
- **2 Pin Tactile Switch (x2):** These are push buttons that the user will press to increase or decrease the temperature threshold. When pressed, they send a signal to the Arduino to adjust the tempThreshold value.
- **5mm LED White:** This LED acts as an indicator. It will turn on when motion is detected by the PIR sensor if the LDR sensor determines that the room is not already bright.
- **Propeller 56mm Four Leaf:** This is the part of the fan attached to the motor that will move the air when the motor is activated.

- **Mini Electric Motor (3V):** This motor will turn on and drive the propeller to act as a fan when the temperature exceeds the threshold and motion is detected.
- **Battery (3.7V):** Powers the electric motor. This is separate from the Arduino's power supply, allowing the motor to run at its required voltage.
- **2N2222 NPN Transistor (x1):** Serves as a switch that allows the Arduino to control the motor.
- **1N4148 Diode (x1):** Placed in parallel with the motor. This diode provides a path for the current when the motor is switched off, protecting the transistor and other components against inductive kickback from the motor.
- **1KΩ Resistor (x3):** These resistors are used to limit the current going into the bases of transistors and to ensure safe switch presses, preventing damage to these components.
- **Breadboard (x1):** A platform for constructing the circuit. It allows for the easy insertion and wiring of components without the need for soldering.
- **Jumper Wires:** Used for circuit connections.

Programming Language:

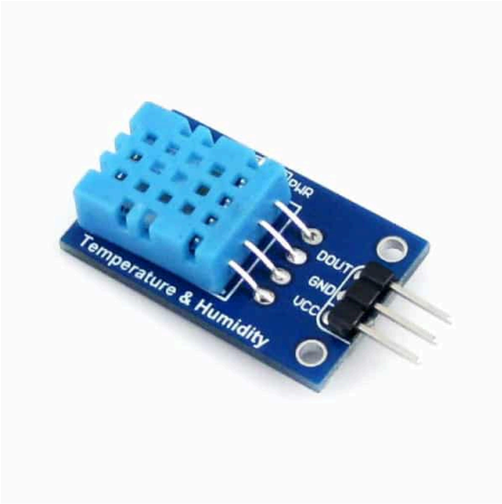
We will be using Arduino IDE, software for writing and uploading the code to the Arduino UNO R3 microcontroller that we will be using, of which the programming language is a variant of C++ programming language.

Working Mechanisms of Sensors

Motion Detection Sensor (PIR)-HC-SR501

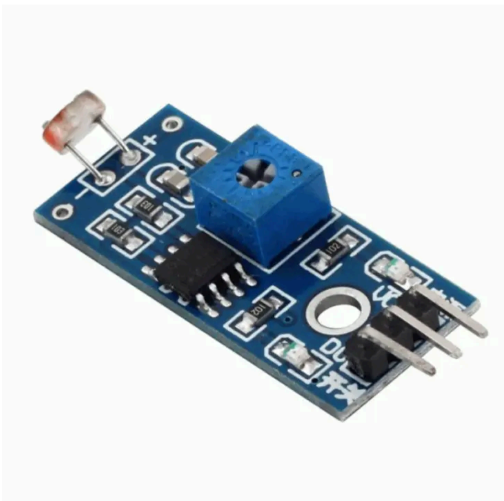
The HC-SR501 sensor of motion detection works on the Infrared radiation (IR) principle, taking notice of changes in infrared radiations that are given out by different objects. In fact, over time, infrared radiation is manifested as well because waves go through the atmosphere and try to interact with objects, which ends up causing a molecule to produce heat. Although humans and animals contribute to the release of infrared rays due to their body temperature. HC-SR501 temperature sensor which takes this opportunity to detect changes in infrared radiation (IR). The change in the radiation is a sign that something is moving. Indication of motion within detection range is provided by the first characteristic of the sensor – pyroelectric sensor arrangement with dual elements. Also, the design of the sensor usually incorporates a dual-element pyroelectric sensor arrangement in order to increase sensitivity to motion detection and to decrease the probability of false alarms. With this detailed setup in place, the sensor offers a smart performance in multiple environments which gives an edge to systems based on security to energy efficient lighting control.

Digital Temperature and Humidity Sensor (DHT11)



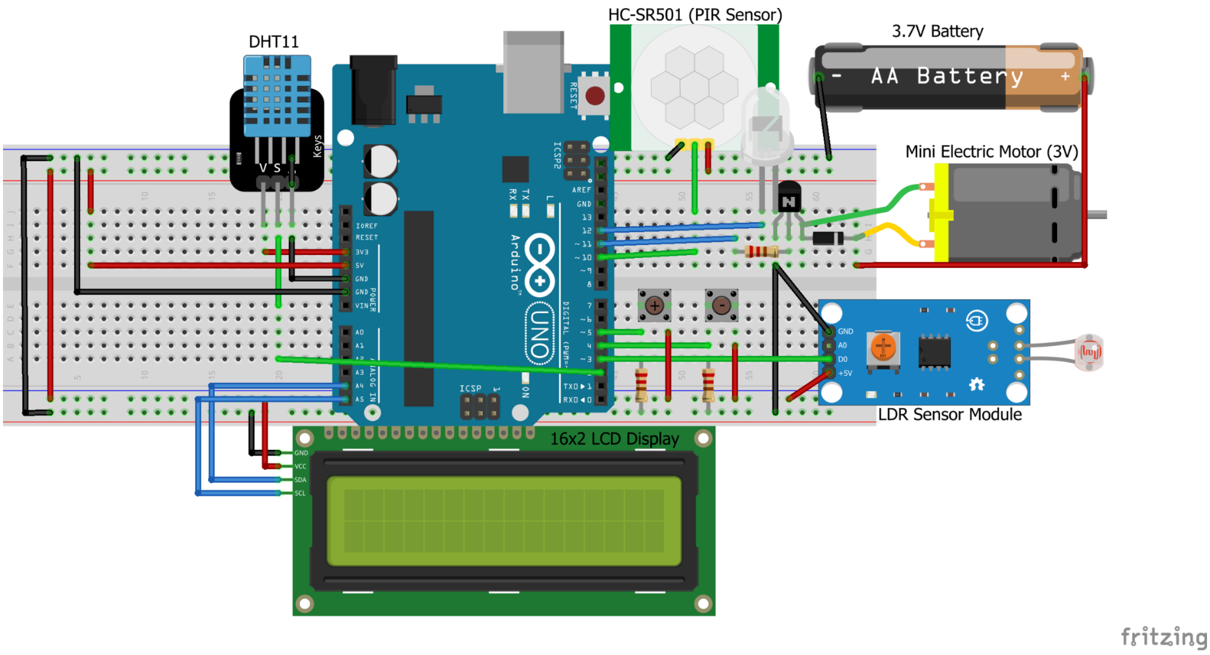
The DHT11 is an ultra-low-cost digital temperature and humidity sensor, offering basic functionality at an affordable price point. It incorporates a capacitive humidity sensor and a thermistor to precisely measure the surrounding air. Operating with a digital signal output on the data pin, it eliminates the need for analog input pins. Although straightforward to use, obtaining accurate data requires precise timing. With a refresh rate of once every 2 seconds, readings from the sensor, when using the Adafruit library, may be up to 2 seconds old. To ensure proper functionality, it's recommended to employ the included 4.7K or 10K resistor as a pullup from the data pin to VCC.

LDR Sensor Module 5V



The LDR sensor module, alternatively known as the Photoresistor sensor, offers both digital and analog functionality at a low cost, making it versatile for various applications. Equipped with an onboard Light Dependent Resistor (LDR), it effectively detects changes in light intensity. With its four terminals, including digital output ("DO") and analog output ("AO") pins, the sensor provides flexibility in signal processing. In the absence of light, the module's output goes high, whereas, in its presence, it goes low, enabling straightforward light detection. Additionally, the sensor's sensitivity can be finely tuned using the onboard potentiometer, allowing users to adjust its performance to suit specific environmental conditions and application requirements.

Connection with IC



Pin Configuration:

- **DHT11 Sensor:**
  - OUT Pin to Arduino Pin D2
  - VCC to Arduino 3.3V
  - GND to Arduino GND

- **16x2 LCD Display with I2C Interface:**
  - SDA to Arduino A4.
  - SCL to Arduino A5.
  - VCC to Arduino 5V.
  - GND to Arduino GND.

- **LDR Sensor Module:**
  - DOUT to Arduino Pin D3.
  - VCC to Arduino 5V.

- GND to Arduino GND.

- **HC-SR501 PIR Sensor:**
    - OUT to Arduino Pin D10.
    - VCC to Arduino 5V.
    - GND to Arduino GND.

- **LED:**
    - Positive Terminal (Anode) to Arduino Pin D12.
    - Negative Terminal (Cathode) to Arduino GND

- **Electric Motor:**
    - Positive Terminal to 3.7V Battery's Positive Terminal.
    - Negative Terminal to the Diode's Negative End.
    - Diode's Positive End to the Collector of the 2N2222 Transistor.
    - The base of the Transistor to Arduino Pin D11 through a 1KΩ resistor.
    - Emitter of Transistor to Arduino GND

- **Temperature Threshold Control Switches:**
    - Plus Switch: One Pin to Arduino 5V, Other Pin to Arduino Pin D5 through a 1KΩ resistor to GND.
    - Minus Switch: One Pin to Arduino 5V, Other Pin to Arduino Pin D4 through a 1KΩ resistor to GND.

Data flow from sensors through ICs to I/O devices

1. DHT11 Sensor:
- Measures temperature and humidity.
- Sends digital signals representing these measurements to the Arduino through Pin D2.

2. LDR Sensor Module:
- Detects the brightness level of the environment.
- Sends a digital HIGH or LOW signal to Arduino Pin D3 depending on the brightness threshold set on the module itself.

3. HC-SR501 PIR Sensor:
- Detects motion.
- Sends a digital HIGH signal to Arduino Pin D10 when motion is detected.

4. Arduino Uno Processing:

- Reads digital signals from DHT11, LDR Sensor Module, and HC-SR501 PIR Sensor.
- Executes programmed logic based on the inputs.
- Outputs control signals to the LED, LCD display, and the motor based on the sensor data and the state of the control switches.

5. LED:
- Receives a digital signal from Arduino Pin D12.
- Turns ON or OFF based on the signal received.

6. Electric Motor:
- Receives power from the 3.7V battery.
- Turns ON or OFF based on the transistor switching, which is controlled by the signal from Arduino Pin D11.

7. 16x2 LCD Display:
- Receives I2C communication from Arduino pins A4 (SDA) and A5 (SCL).
- Displays temperature data and the threshold temperature.

8. Temperature Threshold Control Switches:
- When pressed, they send a signal to Arduino Pins D4 or D5.
- This signal is then used to adjust the temperature threshold up or down.

Code

```
#include <DHT.h>
#include <LiquidCrystal_I2C.h>

// Initializing the DHT sensor
#define DHTPIN 2
#define DHTTYPE DHT22
DHT dht(DHTPIN, DHTTYPE);

// Initializing the LCD
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Defining pin assignments
#define PIR_SENSOR_PIN 9
#define LDR_SENSOR_PIN 3
#define LED_PIN 13
#define TEMP_UP_PIN 5
#define TEMP_DOWN_PIN 4
```

```
#define TRIG_PIN 6
#define ECHO_PIN 7
#define BUZZER_PIN 8
#define SYSTEM_SWITCH_PIN 1

// Motor control pins
int enablePin = 10;
int motorPin1 = 11;
int motorPin2 = 12;

float currentTemp;
int tempThreshold = 35;
bool motionDetected = false;
bool lightDetected = false;
bool motorOn = false;
bool systemOn = true;

unsigned long motionStartTime = 0;
unsigned long motionEndTime = 0;
int count;

void setup() {
  // Beginning serial communication
  Serial.begin(9600);

  // Setting pin modes
  pinMode(PIR_SENSOR_PIN, INPUT);
  pinMode(LDR_SENSOR_PIN, INPUT);
  pinMode(LED_PIN, OUTPUT);
  pinMode(TEMP_UP_PIN, INPUT_PULLUP);
  pinMode(TEMP_DOWN_PIN, INPUT_PULLUP);
  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  pinMode(BUZZER_PIN, OUTPUT);
  pinMode(SYSTEM_SWITCH_PIN, INPUT_PULLUP);

  // Setting motor control pins as outputs
  pinMode(enablePin, OUTPUT);
  pinMode(motorPin1, OUTPUT);
  pinMode(motorPin2, OUTPUT);

  // Starting the DHT sensor
  dht.begin();
```

```
  // Initializing the LCD
  lcd.init();
  // lcd.backlight();
}

void loop() {
  if (digitalRead(SYSTEM_SWITCH_PIN) == LOW) {
    Serial.println("Here");
    if (!systemOn) {
      systemOn = true;
      Serial.println("System turned ON");
    }
    else {
      systemOn = false;
      Serial.println("System turned OFF");
    }
  }
  if (!systemOn) {
    digitalWrite(LED_PIN, LOW);
    digitalWrite(motorPin1, LOW);
    digitalWrite(motorPin2, LOW);
    digitalWrite(BUZZER_PIN, LOW);
    lcd.noBacklight();
    // return;
  }
  else {
  lcd.backlight();

  // Reading from DHT sensor
  currentTemp = dht.readTemperature();

  // Checking for motion
  motionDetected = digitalRead(PIR_SENSOR_PIN) == HIGH;

  // Checking brightness from the LDR sensor (active LOW)
  lightDetected = digitalRead(LDR_SENSOR_PIN) == LOW;

  // Controlling the LED
  if (motionDetected) {
    count = 1;
    motionStartTime = millis();
    activateSonar();
    Serial.println("Motion detected!");
    if (!lightDetected) {
```

```
      digitalWrite(LED_PIN, HIGH);
    }
    else {
      digitalWrite(LED_PIN, LOW);
    }
  }
  else {
    if (count==1) {
    motionEndTime = millis();
    unsigned long duration = motionEndTime - motionStartTime;
    Serial.print("Motion ended. Duration: ");
    Serial.print(duration);
    Serial.println(" ms");
    count--;
    }
    digitalWrite(LED_PIN, LOW);
    digitalWrite(BUZZER_PIN, LOW);
  }

  // Controlling the motor
  motorOn = motionDetected && currentTemp > tempThreshold;
  triggerMotor(motorOn);

  // Checking buttons for adjusting the temperature threshold
  if (digitalRead(TEMP_UP_PIN) == LOW) {
    tempThreshold += 1.0;
    delay(200);
  }
  if (digitalRead(TEMP_DOWN_PIN) == LOW) {
    tempThreshold -= 1.0;
    delay(200);
  }

  // Updating the LCD display
  updateLCD(currentTemp);

  // Adding a small delay to prevent excessive updates
  delay(1000);
  }
}

void updateLCD(float currentTemp) {
  lcd.clear();
  lcd.setCursor(0, 0);
```

```
  lcd.print("Temp: ");
  lcd.print(currentTemp, 1);
  lcd.print(" C");

  lcd.setCursor(0, 1);
  lcd.print("Thr: ");
  lcd.print(tempThreshold, 1);
  lcd.print("C ");
  lcd.print(motorOn ? "Fan ON" : "Fan OFF");
}

void activateSonar() {
  long duration, distance;
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);
  duration = pulseIn(ECHO_PIN, HIGH);
  distance = duration * 0.034 / 2;

  Serial.print("Distance: ");
  Serial.println(distance);

  // int kidPetMaxHeight = 2;
  // int personMinHeight = 5;

  // if (distance > 0 && distance <= kidPetMaxHeight) {
  if (distance > 0 && distance <=6 && distance >3) {
    Serial.println("BUZZER ON");
    digitalWrite(BUZZER_PIN, HIGH); // Turning on buzzer for kids or pets
  }
  // else if (distance > personMinHeight) {
  else {
    Serial.println("BUZZER OFF");
    digitalWrite(BUZZER_PIN, LOW); // Turning off buzzer for regular person
  }
}

void triggerMotor(bool motorOn) {
  if (motorOn) {
    // Spinning the motor forward
    digitalWrite(motorPin1, HIGH);
    digitalWrite(motorPin2, LOW);
```

```
    analogWrite(enablePin, 128);
  } else {
    // Turning the motor off
    digitalWrite(motorPin1, LOW);
    digitalWrite(motorPin2, LOW);
  }
}
```

Estimated cost analysis

No	Name	Quantity	Price Per Quantity (BDT)	Price
1	Arduino Uno R3	1	749/-	749/-
2	PIR Sensor	1	130/-	130/-
3	DHT11 Sensor	1	150/-	150/-
4	LDR Sensor	1	90/-	90/-
5	16x2 LCD Display with I2C Interface	1	200/-	200/-
6	LED (White)	1	10/-	10/-
7	Propeller 56mm Four Leaf	1	60/-	60/-
8	Mini Electric Motor (3V)	1		
9	Battery	1		
10	2-pin Tactile Round Switch	1	15/-	15/-

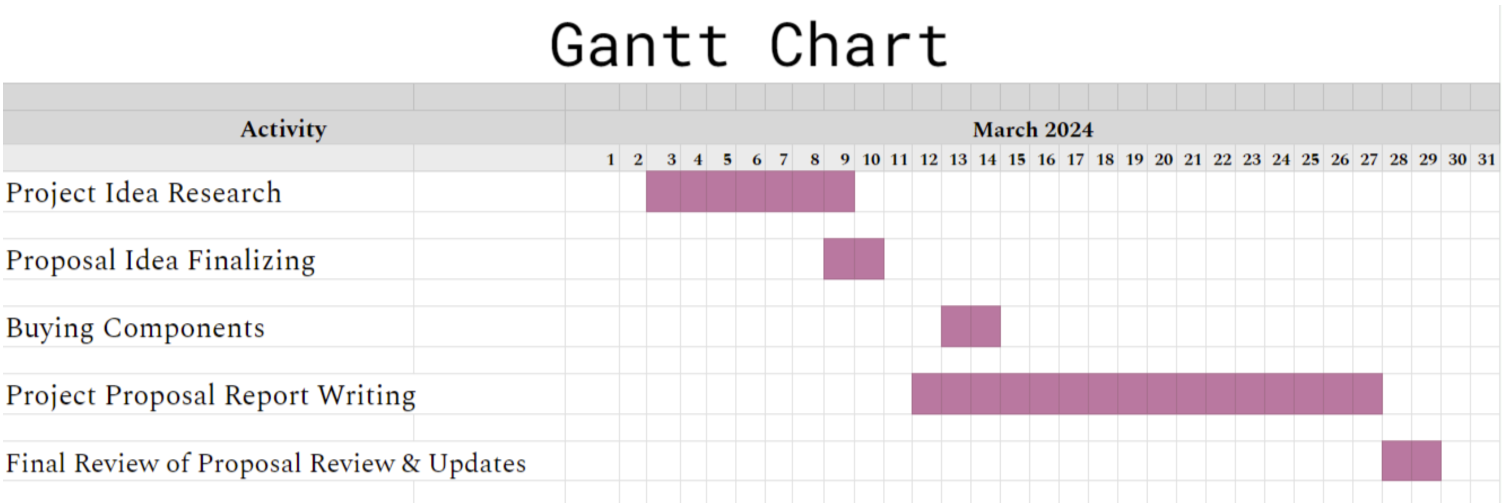
Responsibilities of Each Member

Name	Responsibility
Nafiz Siddiqui Adnan	Circuit Assembling, Coding, Report Writing
Nafisa Muhammad	Circuit Assembling, Report Writing
Abhijit Saha	Circuit Assembling, Report Writing
Md Reaz Uddin	Circuit Assembling, Buying components, Report Writing

Future Work Plan

In our future working plan, we would like to make our Home Automation System more advanced by introducing new technologies and features that will allow higher level functionality and efficiency. It also covers adding more sensors to be able to do a much completive monitoring of the environment. Some of the additional sensors may be air quality monitors and occupancy detectors. Moreover, we will look into the deployment of artificial intelligence along with machine learning techniques to empower the system to cognize the specifications of the user and adapt accordingly with the progress of time. Furthermore, it will be our primary goal to work on privacy and security matters by pursuing and providing a high level of safety to user's data and defending against cyberattacks. Additionally we will keep working in conjunction with the home ecologists and technology experts to establish compatibility with the existing house infrastructure and appliances, thereby giving the clients a hassle free and user-friendly experience.

Workplan (Gantt Chart)



Conclusion

To summarize, the Home Automation System that we have designed is a great way and significant steps toward increasing comfort and efficiency of everyday life.The automated control of lights and fans, does not require human engagement. Instead, people can do other useful jobs. The system's smartness goes beyond as did regulation of lighting depending on the outside environment and adjusting of fans based on the indoor temperature. On the top, the inclusion of a screen allows users to do some customization of the fan's settings by adjusting them to their liking.

Ahead of us there are the opportunities for more in depth research and application of home automation. Next versions of this platform can be augmented with air quality sensors and occupancy detectors for more accurate environmental monitoring.

Overall, our Home Automation System has a lot of pluses from the convenience, to the energy saving and customization, and further development as well as careful consideration of the potential challenges are required in order to reach the maximum level of the comfort and safety in our user's residential systems.

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