IOT based Environmental Monitoring System

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PROJECT REPORT

This Report Presented in Partial Fulfillment of the course

CSE234: Embedded Systems and IoT Lab in the Department of Computer Science and Engineering

DAFFODIL INTERNATIONAL UNIVERSITY

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DECLARATION

We hereby declare that this lab project has been done by us under the supervision of Indrojit Sarkar, **Lecturer**, Department of Computer Science and Engineering, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere as lab projects.

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Chapter 1

Introduction

1.1 Introduction

This project introduces a real-time, portable environmental monitoring system that measures ultraviolet (UV) radiation, temperature, and humidity using ESP32. The system uses the GY-8511 UV sensor and AM2320 temperature & humidity sensor. It displays data on a 16x2 LCD and uploads it to ThingSpeak cloud for real-time remote monitoring. The system is especially useful for outdoor workers, students, and the general public. This project focuses on the design and development of a portable, real-time environmental monitoring station using the ESP32 microcontroller. The system integrates a GY-8511 UV sensor for UV intensity measurement, an AM2320 digital temperature and humidity sensor for atmospheric data, and a 16x2 LCD with I2C interface for instant on-site display. The device is capable of sending sensor data to the ThingSpeak IoT cloud platform, enabling remote tracking and visualization through a real-time dashboard.

1.2 Motivation

Prolonged exposure to UV radiation can be harmful. Outdoor workers and students need a way to check environmental conditions instantly. This motivated us to build a compact, energy-efficient weather station that displays and stores data online, improving public awareness and safety. While weather applications on smartphones provide forecasts, they often lack **real-time local UV measurements** and immediate on-site alerts. This motivated the development of a **standalone, IoT-enabled environmental monitoring system** that can function both independently and as part of a broader network of weather stations.

1.3 Objectives

- Measure UV, temperature, and humidity.
- Display values on an LCD in real-time.
- Store sensor data in ThingSpeak.
- Trigger alerts if UV exceeds safe levels
- Ensure portability and reliability of the system.

1.4 Feasibility Study

Various weather stations and mobile apps exist (e.g., AccuWeather), but few provide **real-time UV readings with alerts** using **low-cost embedded systems**. Existing systems often lack physical displays or cloud storage integration. From an **economic perspective**, the components required are affordable and readily available in local markets or online platforms. Operationally, the device can be powered by USB adapters, power banks, or potentially solar panels for long-term deployment. The system's reliance on cloud storage ensures that data can be accessed from anywhere without the need for physical retrieval.

1.5 Gap Analysis

Many low-cost weather stations do not include UV radiation measurement or real-time alerts. Our system addresses this gap by combining **sensing, display, cloud storage, and safety alerts** in one portable design. Existing solutions in the market such as commercial weather stations are often **expensive, bulky, and designed for permanent installation**. Mobile applications, while more accessible, rely heavily on satellite data and general regional forecasts, which may not reflect real-time local conditions. Our system addresses this gap by providing:

- **On-site measurement of UV, temperature, and humidity** in real-time.
- **Visual and audible alerts** for unsafe UV levels.
- **Cloud data logging** for long-term environmental pattern analysis.
- **Portability** for flexible deployment in multiple locations.

1.6 Project Outcome

The outcome of this project is a fully functional portable environmental monitoring system capable of accurately measuring ultraviolet radiation, temperature, and humidity in real time. The device successfully integrates the GY-8511 UV sensor and AM2320 temperature-humidity sensor with the ESP32 microcontroller, enabling seamless data acquisition and processing. The readings are clearly displayed on a 16x2 LCD using the I²C interface, ensuring efficient communication and reduced wiring complexity.

- A working prototype that continuously monitors and displays environmental data.
- Cloud-based data logging system via ThingSpeak.
- Alert system for high UV conditions.
- A functional, portable environmental monitoring prototype.
- A ThingSpeak IoT dashboard displaying UV, temperature, and humidity trends over time.
- Documentation detailing the design, implementation, testing, and potential improvements for the system.

Chapter 2

System Architecture

2.1 Requirement Analysis & Design Specification

2.1.1 Requirements

1. Sensors collect data
2. ESP32 processes the input
3. LCD displays output
4. LED trigger alert on high UV
5. Data is sent to ThingSpeak channel

2.1.2 Equipment

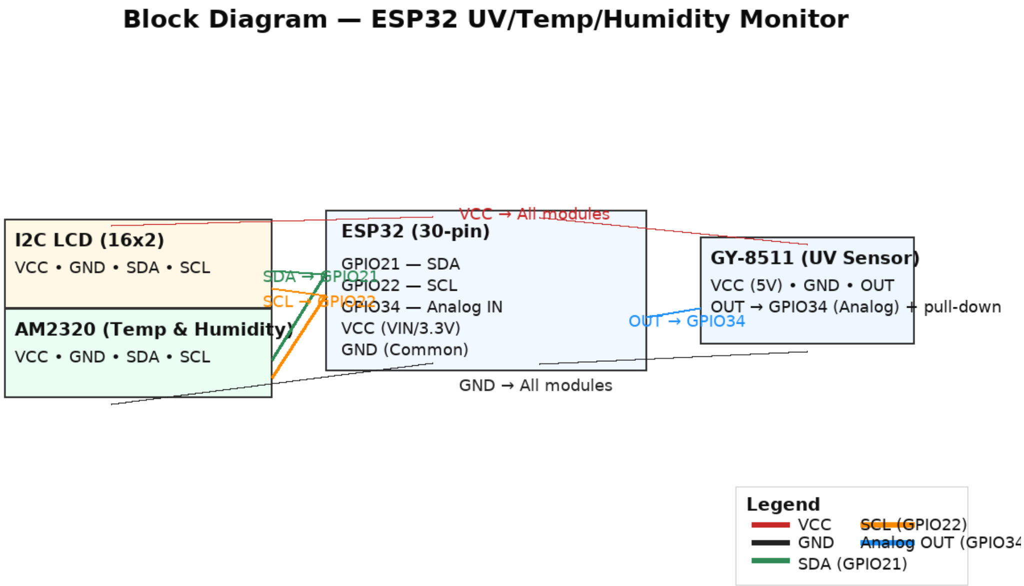
- ESP32 (30-pin) microcontroller
- GY-8511 UV Sensor
- AM2320 Temperature & Humidity Sensor
- 16x2 LCD with I2C Module
- Jumper Wires, Breadboard, Power Source

2.1.3 Use of Modern Tools

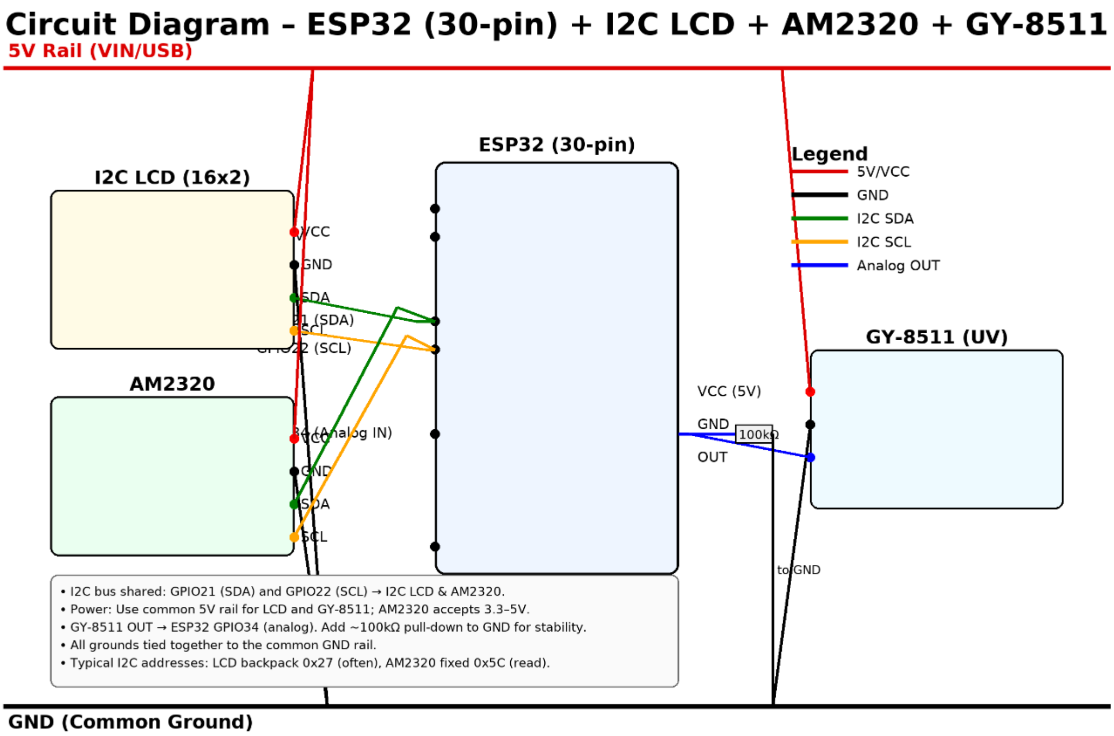
- **Arduino IDE** – Code development and flashing
- **ThingSpeak** – Cloud-based IoT platform for data visualization
- **I2C Communication** – For LCD and AM232

2.2 Diagram

2.2.1 Block Diagram



2.2.2 Circuit Diagram

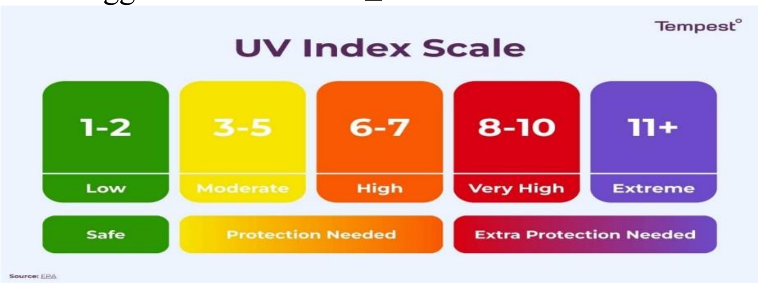


Chapter 3

Implementation and Results

3.1 Implementation

- AM2320 and LCD share I2C pins (SDA: GPIO21, SCL: GPIO22)
- GY-8511 outputs analog signal (read via GPIO34)
- ESP32 uploads data every 15 seconds to ThingSpeak
- LED on GPIO26 and GPIO2 respectively
- Alert triggered at UV Index ≥ 3



Code:

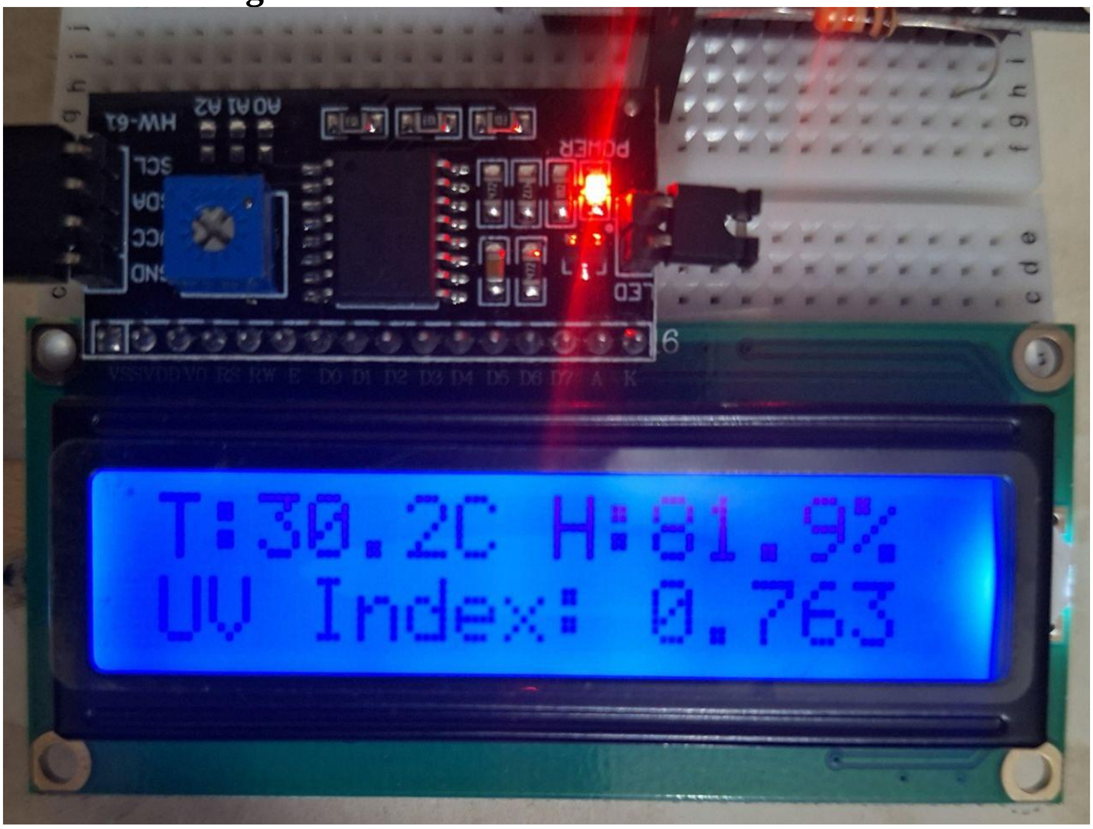
```
#include <WiFi.h>
#include <ThingSpeak.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include "Adafruit_AM2320.h"

// ==== WiFi & ThingSpeak Config ====
const char* ssid = "iot";
const char* password = "244466666";
unsigned long myChannelNumber = 3021698;
const char* myWriteAPIKey = "FYGLQS1G8WVG3BQ7";
WiFiClient client;

// ==== Sensor & LCD Setup ====
Adafruit_AM2320 am2320 = Adafruit_AM2320();
LiquidCrystal_I2C lcd(0x27, 16, 2); // Try 0x3F if 0x27 doesn't work

// ==== Pin Config ====
#define UV_SENSOR_PIN 34     // GY-8511 OUT to D34

// ==== UV Threshold ====
#define UV_THRESHOLD 3.0     // Alert if UV index > 3.0

void setup() {
  Serial.begin(115200);

  // LCD
```

```
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Initializing...");

  // Sensor
  Wire.begin();
  am2320.begin();

  // WiFi
  WiFi.begin(ssid, password);
  lcd.setCursor(0, 1);
  lcd.print("Connecting WiFi");
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("WiFi Connected");

  // ThingSpeak
  ThingSpeak.begin(client);
  delay(2000);
}

void loop() {
  // ==== Read Sensors ====
  float temperature = am2320.readTemperature();
  float humidity = am2320.readHumidity();
  int uvRaw = analogRead(UV_SENSOR_PIN);
  float uvVoltage = (uvRaw / 4095.0) * 3.3;  // ESP32 ADC 12-bit
  float uvIndex = (uvVoltage - 1.0) * 10.0;  // Approx. for GY-8511
  if (uvIndex < 0) uvIndex = 0;

  Serial.printf("Temp: %.2f C, Hum: %.2f %%, UV: %.2f\n", temperature, humidity, uvIndex);

  // ==== Display on LCD ====
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("T:");
  lcd.print(temperature, 1);
  lcd.print("C H:");
  lcd.print(humidity, 0);
  lcd.print("%");

  lcd.setCursor(0, 1);
  lcd.print("UV Index: ");
  lcd.print(uvIndex, 1);
```

```
  // ==== UV Alert ====
  if (uvIndex > UV_THRESHOLD) {
    lcd.setCursor(0, 1);
    lcd.print("!! High UV Alert ");
  }

  // ==== Send to ThingSpeak ====
  ThingSpeak.setField(1, temperature);
  ThingSpeak.setField(2, humidity);
  ThingSpeak.setField(3, uvIndex);

  int statusCode = ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);
  if (statusCode == 200) {
    Serial.println("Data sent to ThingSpeak.");
  } else {
    Serial.print("Error sending data: ");
    Serial.println(statusCode);
  }

  delay(20000); // 20s delay (ThingSpeak minimum)
}
```

3.2 Output

Hardware Design :



ThingSpeak :

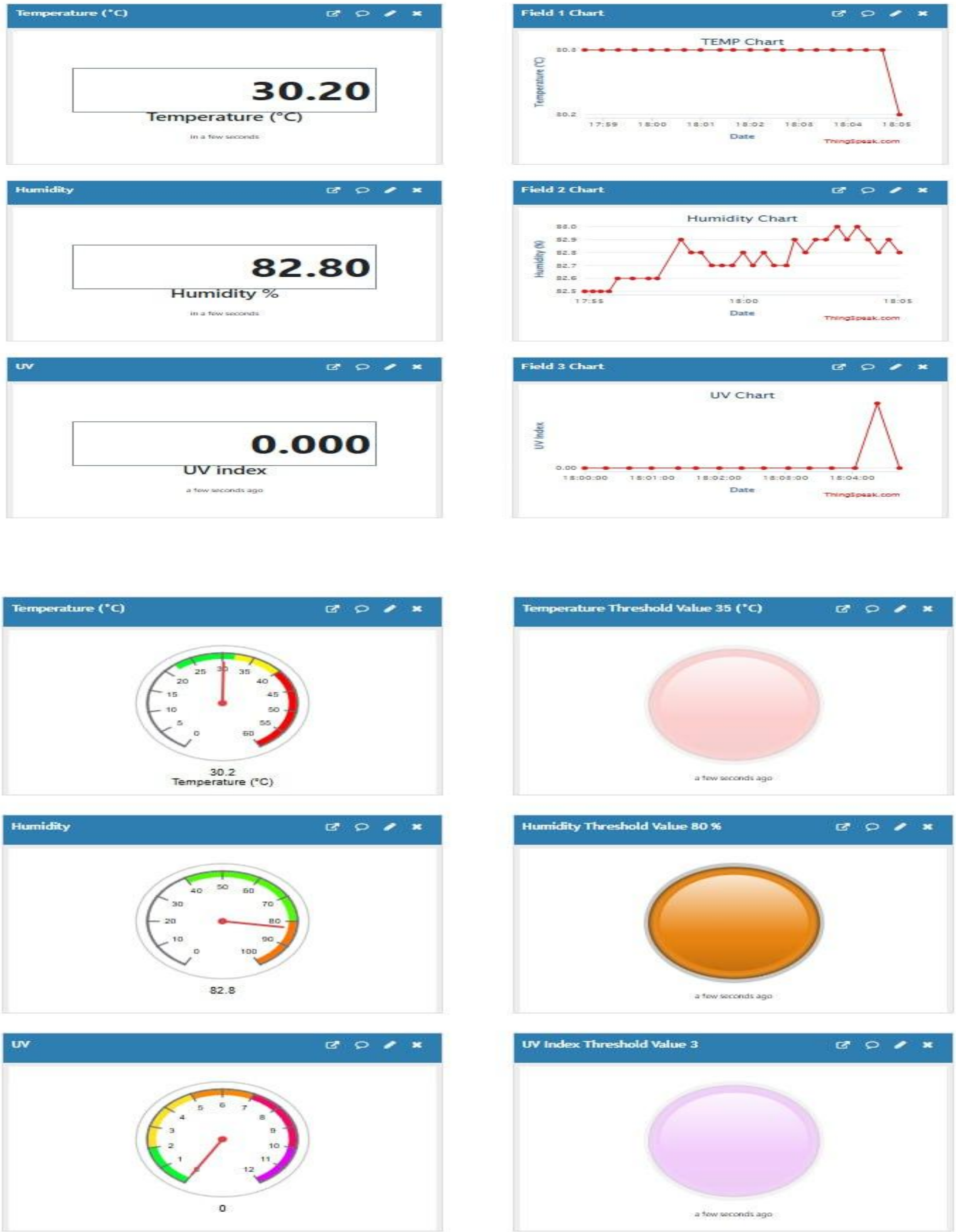


Figure : ThingSpeak Displays graphs of Temperature, Humidity, UV in real-time

3.3 Dataset

3.4.1 Description

The dataset used in this project is collected from an IoT-based environmental monitoring system**.** It contains sensor readings recorded over time at a specific location. The data provides useful insights into environmental conditions such as temperature, humidity, and UV index, which are essential for remote monitoring applications.

Number of Records: 241

Number of Features: 6

ID	Place	Date?Time	Temperatur	Humidity	UV
1	bonomaya	2025-08-11T13:14:55+	33.8	76	3
2	bonomaya	2025-08-11T13:15:17+	33.7	75.9	2
3	bonomaya	2025-08-11T13:15:39+	33.7	76	2.456
4	bonomaya	2025-08-11T13:16:00+	33.6	76.2	3.456
5	bonomaya	2025-08-11T13:16:26+	33.7	76.6	4.456
6	bonomaya	2025-08-11T13:16:49+	33.7	77.1	5.456
7	bonomaya	2025-08-11T13:17:10+	33.8	77.7	4
8	bonomaya	2025-08-11T13:17:33+	33.8	78	1
9	bonomaya	2025-08-11T13:17:55+	33.8	78.1	0.567
10	bonomaya	2025-08-11T13:18:18+	33.7	78.2	3
11	bonomaya	2025-08-11T13:18:40+	33.8	78.1	2
12	bonomaya	2025-08-11T13:19:02+	33.8	78.1	1
13	bonomaya	2025-08-11T13:19:24+	33.8	78	1.345
14	bonomaya	2025-08-11T13:19:45+	33.8	77.9	1.269
15	bonomaya	2025-08-11T13:20:07+	33.8	78	2.349
16	bonomaya	2025-08-11T13:20:28+	33.8	78.1	2.135
17	bonomaya	2025-08-11T13:20:50+	33.8	78.2	2.135
18	bonomaya	2025-08-11T13:21:11+	33.9	78.1	2.135
19	bonomaya	2025-08-11T13:21:33+	33.9	78.1	2
20	bonomaya	2025-08-11T13:22:18+	33.9	77.9	1.224
21	bonomaya	2025-08-11T13:22:40+	33.8	77.8	1.324
22	bonomaya	2025-08-11T13:23:01+	33.9	77.8	3
23	bonomaya	2025-08-11T13:23:23+	33.9	78.1	2.982
24	bonomaya	2025-08-11T13:23:44+	33.9	78.2	0
25	bonomaya	2025-08-11T13:24:06+	33.9	78.5	1.981
26	bonomaya	2025-08-11T13:24:27+	33.9	78.8	2.217
27	bonomaya	2025-08-11T13:24:49+	33.8	78.7	1.896
28	bonomaya	2025-08-11T13:25:10+	33.6	78.3	2.234

Attributes

1. **ID** *(Integer)* – Unique identifier for each record.
2. **Place** *(String)* – Location where the IoT sensors were deployed (e.g., *bonomaya*).
3. **DateTime** *(Timestamp)* – Date and time when the sensor reading was recorded (in ISO 8601 format with timezone).
4. **Temperature (°C)** *(Float)* – Ambient temperature measured by the IoT sensor.

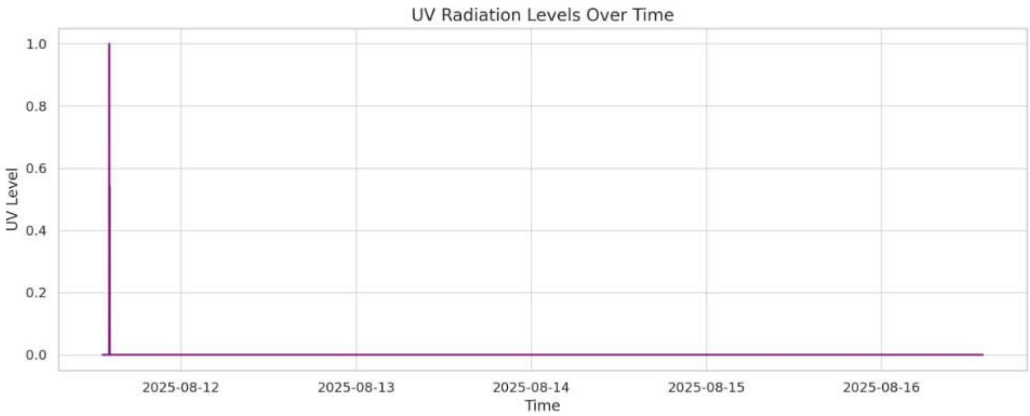
5. **Humidity (%)** *(Float)* – Relative humidity percentage.
6. **UV (Index)** *(Float)* – Ultraviolet index value, representing solar UV radiation intensity.

Data Characteristics

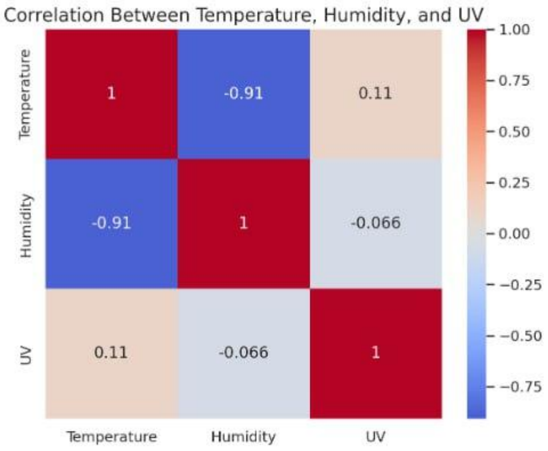
- The dataset is time-series in nature, as observations are recorded sequentially with precise timestamps.
- The values are numeric for sensor readings and categorical for location.
- Temperature ranges around **33–34 °C**, humidity around **75–77%**, and UV index is recorded as **0.0** during the observation period (indicating low/no UV radiation at the recorded times). Because when the data was recorded the weather was cloudy.

3.4.2 Visualization

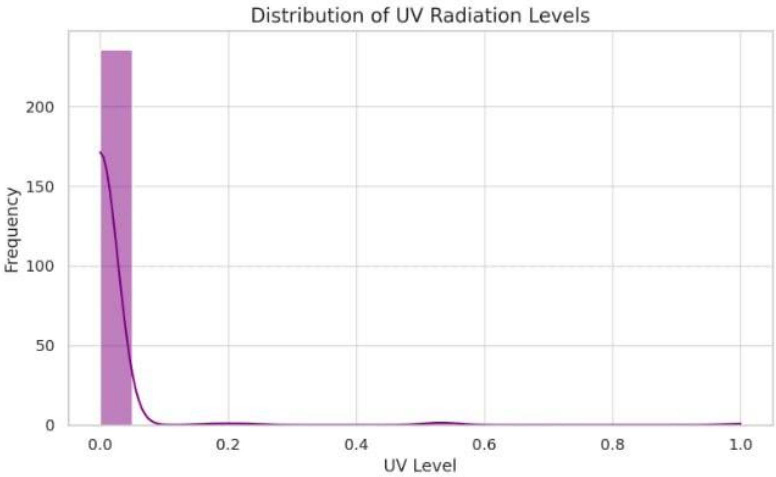
1. UV Radiation Levels Over Time
   - This time-series plot shows how UV levels fluctuate over time.
   - If values remain mostly near 0, it indicates low or no harmful exposure during the recorded period.
   - Peaks (if present) highlight periods of higher UV radiation risk.



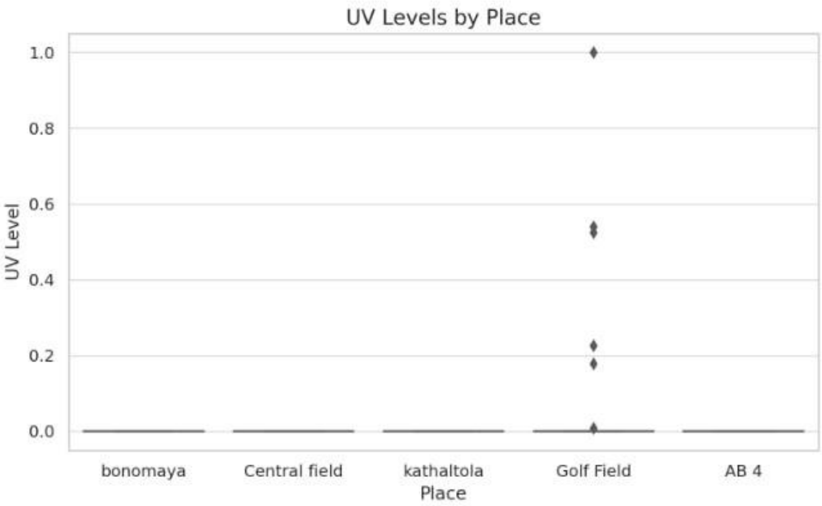
2. Correlation Between Temperature, Humidity, and UV
   - This heatmap shows how strongly the variables are related.
   - A value close to 1 or -1 indicates a strong positive/negative relationship.
   - Example: If UV correlates positively with temperature, it means higher temperatures may come with higher UV exposure.



3. Distribution of UV Radiation Levels
    - This histogram + KDE shows the spread of UV readings.
    - If most readings cluster near 0, exposure risk is low.
    - A wider spread means varying UV conditions (daytime vs evening, sunny vs cloudy).

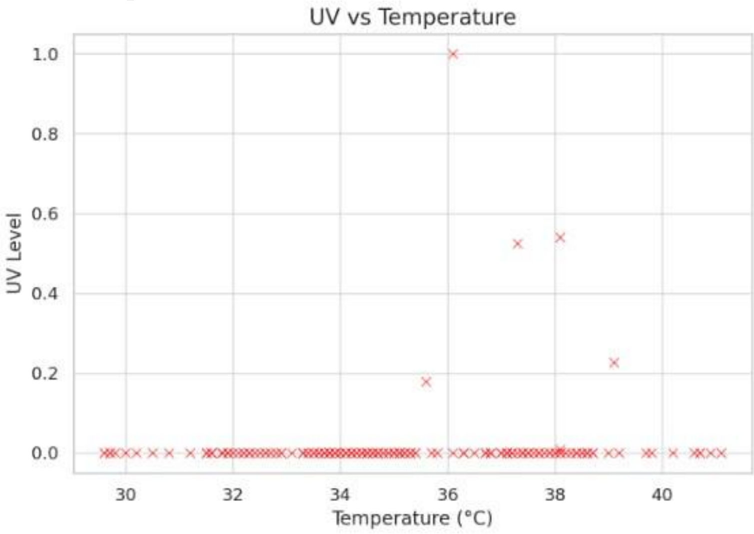


4. UV Levels by Place
    - This boxplot compares UV exposure across different locations.
    - Useful if you have multiple monitoring places (e.g., urban vs rural).
    - You can easily see which places tend to have higher or more variable UV exposure.



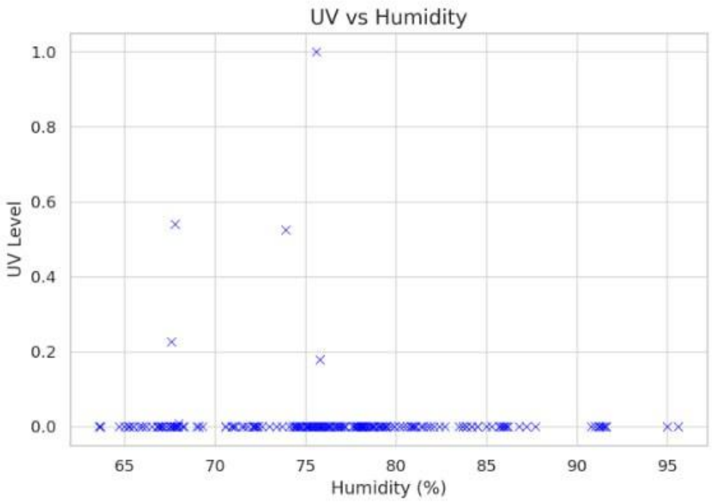
5a. UV vs Temperature

- This scatterplot checks the relationship between temperature and UV radiation.
- If points trend upward, it means higher temperatures are linked to stronger UV exposure.



5b. UV vs Humidity

- This scatterplot shows the relationship between humidity and UV.
- If points slope downward, it may indicate that higher humidity reduces UV radiation, possibly due to cloudiness or water vapor.



3.4 Discussion

The system runs stably with low power. UV readings vary as expected with light exposure. LCD readability and I2C communication are reliable. Cloud integration is successful. The **16x2 LCD with I2C backpack** minimized wiring complexity, reducing the number of required GPIO pins and simplifying troubleshooting. While performance was stable, some limitations were noted.

Chapter 4

Engineering Standards and Mapping

4.1 Impact on Society, Environment and Sustainability

4.1.1 Impact on Life

Informs users of weather and UV exposure. Useful for farmers, students, construction workers, and the general public. The developed IoT-based environmental monitoring station directly contributes to improving quality of life by enabling individuals to make informed decisions regarding their outdoor activities.

4.1.2 Impact on Society & Environment

Helps avoid excessive sun exposure, potentially reducing skin-related health risks. Promotes environmental awareness and personal safety. The proposed IoT-based environmental monitoring system has a significant impact on society by enhancing public awareness about real-time weather and UV conditions. By making accurate environmental data accessible to anyone, it encourages individuals and communities to adopt healthier outdoor habits, such as limiting exposure during high UV index periods. The system can be deployed in public spaces such as parks, schools, and workplaces, allowing people to make informed decisions on the spot.

4.1.3 Ethical Aspects

In this IOT based project, data privacy is ensured as no personal data is stored. Uses open-source software and responsible use of cloud resources. The project also promotes equitable access to environmental information, allowing communities, schools, and workplaces to benefit from accurate, real-time data without requiring costly infrastructure. In addition, the system adheres to electrical safety norms by using low-voltage components, ensuring safe operation for users of all ages. Transparency is maintained through open access to ThingSpeak dashboards, enabling anyone to verify the accuracy and integrity of the collected data.

4.1.4 Sustainability Plan

The system is energy-efficient. It can be solar-powered for long-term use. Maintains low component cost and easy replicability.The affordability of the components makes the system accessible to schools, communities, and small organizations, encouraging widespread adoption. By promoting environmental awareness and responsible outdoor behavior, the project contributes indirectly to the preservation of public health.

Chapter 5
Conclusion

5.1 Summary

This project successfully built a real-time monitoring system for UV, temperature, and humidity. It displays data locally and uploads it to the cloud with alert features. In addition to local display, the system uploads all readings to a ThingSpeak IoT platform, enabling remote monitoring, data visualization, and long-term trend analysis. To enhance safety, a LED alert mechanism is activated whenever UV levels exceed a defined hazardous threshold (UV Index ≥ 3).

5.2 Limitation

While the system performs well in its intended application, several limitations exist. The current prototype requires an active Wi-Fi connection for cloud integration, limiting its usability in remote areas without internet access. The system's power source is presently dependent on USB or power bank supply, meaning continuous operation relies on manual charging or constant connection to a power source.

- No battery or solar integration yet
- Internet required for ThingSpeak
- Limited LCD display characters

5.3 Future Work

Future developments can focus on improving both hardware and software capabilities. Incorporating a rechargeable battery with solar panel integration would enhance portability and allow for long-term autonomous operation. Replacing the 16x2 LCD with a larger display, such as a TFT screen, could present more information simultaneously, including graphical trends. Adding more sensors, such as air quality, particulate matter (PM2.5), or rainfall detection, would extend the system's functionality into a more comprehensive micro-weather station.

- Add mobile app for live tracking
- Solar power and battery backup
- More environmental sensors (e.g., CO_2, Rainfall)

References

[1] Adafruit AM2320 Sensor Library
[2] ThingSpeak IoT Cloud Platform – https://thingspeak.com/
[3] Arduino I2C LCD Library
[4] GY-8511 Datasheet – Vishay Semiconductors
[5] ESP32 Technical Reference Manual – Espressif
[6] https://tempest.earth/resources/what-is-the-uv-index/