**IDIVIDUAL ASSIGNMENT (PRACTICAL)**

How IOT contribute to agriculture development

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# Summary

## Topic background

The emergence of the Internet of Things (IoT) has ushered in a transformative era, reshaping industries across the globe. One sector profoundly impacted is agriculture, where the interconnectivity of devices and data-driven practices are revolutionizing traditional farming methods. In this context, my survey paper delves into the multifaceted influence of IoT innovation on agriculture, exploring its implications from precision farming to sustainable practices.

Traditionally, agriculture has been characterized by tradition and manual labor. However, with the surge in global population and escalating environmental concerns, the necessity for more efficient, sustainable, and data-driven approaches to farming has become increasingly apparent. The integration of IoT into agriculture provides a technological frontier that addresses age-old challenges. This paper investigates how IoT enables farmers to remotely oversee their land and crops, receiving critical updates and insights on their smartphones or personal devices. This level of connectivity affords an unprecedented level of control and responsiveness, empowering farmers and citizens alike to take timely actions to mitigate potential risks and losses.

In the realm of farming practices, the integration of IoT technologies has ushered in a new era of agricultural management and efficiency. Sustainable farming practices have been significantly bolstered by IoT. The continuous monitoring of environmental conditions facilitated by IoT assists in pest management and disease prevention.

A proposed smart agriculture system for cornfields, utilizing wireless sensor networks and drones, is scrutinized for its benefits and limitations. The need for many sensors and the cost of drones are identified as challenges, despite the potential to improve crop yields.

Lastly, the survey explores a smart farming system based on IoT sensors for data collection and cloud computing for analysis. Machine learning is employed to provide farmers with recommendations on enhancing crop yields and reducing environmental impact. Emphasizing the real-time data collection capabilities of IoT sensors, enabling farmers to make informed decisions for improved crop yields, reduced costs, and environmental sustainability. While acknowledging the transformative power of IoT, the survey paper also highlights existing challenges such as high costs and complexity that need addressing for widespread adoption in agriculture. As IoT continues to evolve, its role in agriculture is poised to grow, contributing to a more efficient, profitable, and sustainable future for farmers and industry.

## Proposed system

A black and white computer icons

Description automatically generated

*Figure 1: Sketch of proposed system*

The proposed system consists of the following components:

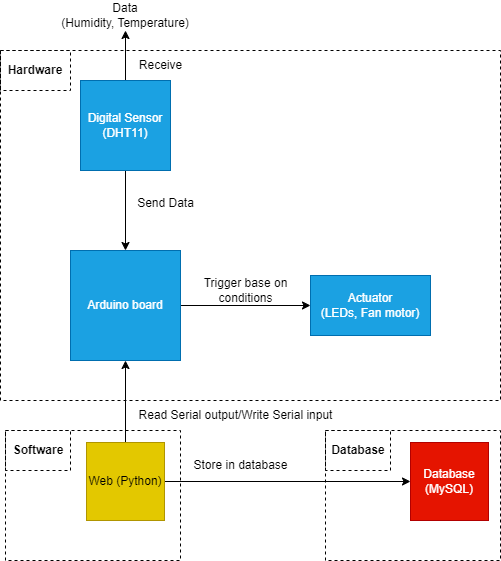
* Sensors: The sensors collect data about the environment, such as temperature and humidity.
* Edge server: the edge server collects data from the sensors and processes it in real time. It also can be used to write serial input into the Arduino board.
* Database: The database stores the data collected by the sensors and the edge server.

The clients can interact with the system through web browsers. This proposed system offers several benefits including Real-time monitoring, distributed architecture, and scalability. The system can monitor the real-time and detect changes immediately, allowing the system to respond to changes quickly and alert through actuators. The components of the system are in different places and make the system more scalable and reliable and can be expanded by adding more sensors and actuators. This system can help to monitor and control devices in an agriculture setting such as irrigation systems and greenhouses. This system also involves the use of storage MySQL and can store both humidity, temperature, and current time stamp for managing.

For the sensor for collecting humidity and temperature, DHT22 is suitable for this use case, but humidity will be mainly used for controlling the system. Humidity is about 60% - 80% is ideal for plants (PLNTS.com, 2021) but in this assignment I will change the humidity for trigger conditions so that changes in humidity can be easier to managed.

# Conceptual Design

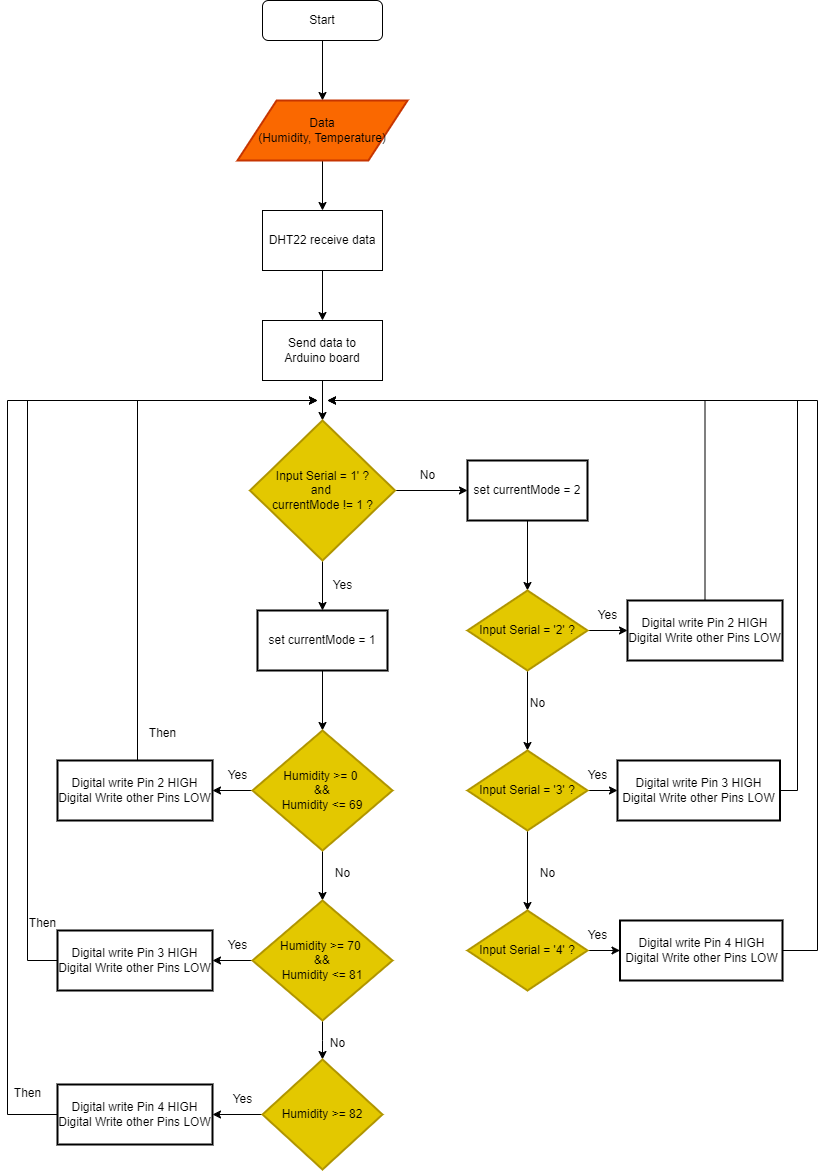
## Block diagrams



*Figure 2: Block diagram for proposed system*

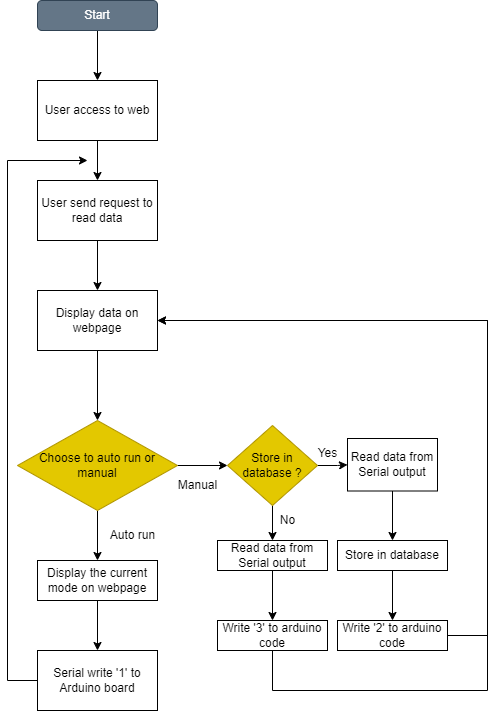
First, the digital sensor (DHT11) will receive the data (Humidity and Temperature) from the environment then it will send the data to the Arduino board. Based on the data and conditions, the Arduino board will trigger the actuator (LEDs) for notifying. The web application can show the front end and read the serial output from the Arduino board and display the data. Depending on the user, the web application can perform the action to store the data to the database (MySQL).

## UML diagram



*Figure 3: Flow chart for how the Arduino work*

For the above chart, the Arduino code runs in the order and keeps looping. The data are humidity and temperature will be received from the DHT22. It can be divided into 2 modes: for the first mode when the user input ‘1’ to the Arduino, the code will automatically run and detect the humidity it receives from the DHT22 sensor. If the user enters ‘2’ or ‘3’ or ‘4’ to the Arduino, the current mode will switch to 2 and perform the action of setting the corresponding pin to HIGH and other pins to LOW state.



*Figure 4: Flow chart for how the python program works and send request.*

For the above image, the description of the system is visualized. First, when the user accesses the web, the webpage will display and then when the user requests the data, the data will be fetched by Python and display back in the web. The user can choose whenever the Arduino runs automatically or manually for managing the state. If the user chooses to run automatically, the back end of the website will write the Serial input to the Arduino board and the program will auto run (refer to Figure 3). However, if the user chooses to run manually, the user can choose whenever to store the data in the database or not. In both cases, the first thing the backend of the web does is to read the data (humidity and temperature) from the Serial output. If the user chooses to store, the backend of the web will store the data (humidity, temperature) in the database include the time and date of the current request. the backend of the web will send Serial input ‘2’ to the Arduino code and then the Arduino board will trigger the suitable pin to alert (refer to Figure 4).

# Implementation

The Arduino servers as a node, collecting and processing data from sensors and sending it to the edge server. The edge server processes this data further and communicates with a high-level system and displays it on web page. The edge server powered by Python and Flask communicates with Arduino through serial communication, fetching sensor data and sending control signals.

## Sensors

DHT is a sensor for measuring the temperature and humidity of the surrounding environment. In this project, DHT is used to monitor the environmental conditions. This is crucial for applications such as climate control or data logging where knowing temperature and humidity is essential. The DHT22 is integrated with Arduino, which reads the sensor values and prints out Serial output in the customized format. It can take actions based on the data retrieved.

## Actuators

1. LED is used in this project for status display. It can help to signal the specific conditions when the data received meets one of the conditions such as turning on it when a certain temperature is reached. It is integrated with the Arduino and controlled by the program logic to provide visual feedback.
2. Fan motor serves as drying the humidity based on the humidity readings from the DHT22. If the humidity goes over the at some point, the fan motor activates to dry the environment. Integrating with the Arduino enables automated humidity control and is crucial for real-life applications like cooling systems.

## Software/Libraries:

Python is one of the programming languages used in this project along with its libraries like MySQLdb, serial, Flask, render\_template is used for employing data processing, communication and front-end. Python interacts with the Arduino via the serial port, retrieving sensor and storing it in a MySQL database. Flask and render\_template will facilitate the creation of a web interface for users to monitor and control the system by sending requests to the programmed endpoints.

MySQL will serve as the database to store sensor data. This relational database system allows efficient management and retrieval of information which will support storing and managing all the records including time and date information. This can help for analyzing the temperature and humidity patterns.

# Evidence of system

## Tinkercad Model

A circuit board with wires

Description automatically generated

*Figure 5: Tinkercad Model of proposed system*

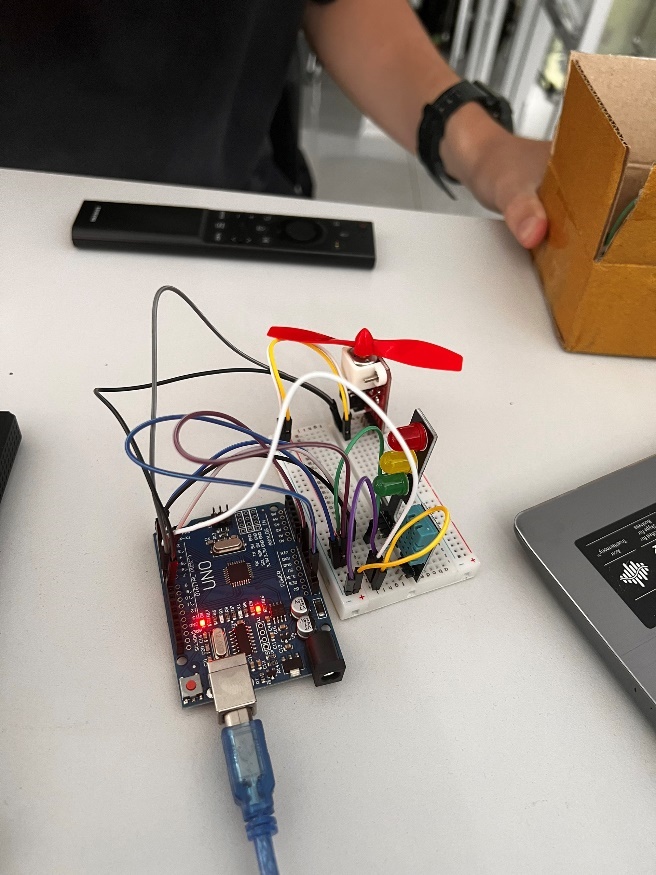
Due to Tinkercad doesn’t have the suitable motor for my proposed system, so I have replaced it with the buzzer for displaying. However, the functionality is still the same. The system will alert based on the conditions of the code. Below is the schematic view which includes the logic of the circuit.

A diagram of a circuit board

Description automatically generated

*Figure 6: Schematic view of Tinkercad*

## Evidence of building system

**

*Figure 7: Side view of proposed system*

*A circuit board with wires and a fan

Description automatically generated*

*Figure 8: Front view of proposed system*

## Evidence of full process

**Base URL**: <http://192.168.153.131/>

**Command**:

Note: If there is any process fail, the Arduino will receive the Serial input 4 and will trigger red light for alerting the error.

* Get current data. (URL/getData)
  + This will get the current data from the sensor and display it on the web.

A screenshot of a computer

Description automatically generated

*Figure 9: Get current data command.*

* Run automatically. (URL/automatically)
  + This will write the Serial input 1 into the Arduino code and the system will run automatically based on the logic.

A white background with black and red text

Description automatically generated

*Figure 10: Automatically run command.*

* Get data and store data into database. (URL/storeData)
  + This will include getting current data and storing it into the database. It also will write the Serial input 2 into the Arduino board and trigger green light.

A white background with black dots

Description automatically generated

*Figure 11: Store database is currently on*

* Get data and no store data into database. (URL/noStoreData)
  + Get the current data and turn the mode of database to off.

A white background with black dots

Description automatically generated

*Figure 11: Current database is off.*

* Get data from database. (URL/getDatabase)
  + Get the records from the database and display them on the web page.

A screenshot of a data

Description automatically generated

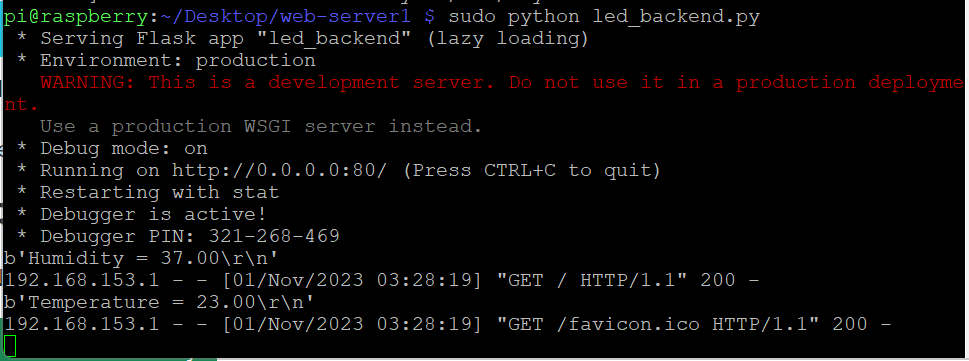
*Figure 12: Table for displaying records.*

**Database** **of records**:  
A computer screen shot of a computer screen

Description automatically generated

*Figure 13: Show the records from database with query.*

**Command line to run server:**

  
*Figure 14: Run server.*

Explanation of C++ for Arduino board:

#include "dht.h"  //include library

dht DHT;

#define DHT11\_PIN 7 //set Pin 7 (LED)

int pin2 = 2; //set Pin 2 (LED)

int pin3 = 3; //set Pin 3 (LED)

int pin4 = 4; //set Pin 4 (LED)

int INA = 9; // set Pin 9(Fan motor)

int INB = 8; //set Pin 8(Fan motor)

int currentMode = 0; // default of mode is 0

void setup() {

  pinMode(pin2, OUTPUT);

  pinMode(pin3, OUTPUT);

  pinMode(pin4, OUTPUT);

  pinMode(INA, OUTPUT);

  pinMode(INB, OUTPUT);

  //Set default of Fan to low

  digitalWrite(INA, LOW);

digitalWrite(INB, LOW);

  Serial.begin(9600);

}

void loop() {

int value = Serial.read(); //Read the Serial input

if (value == '1' && currentMode != 1) { // if the Serial input is 1 and current mode is not 1

currentMode = 1; // set current mode = 1 (automatically)

} else if ((value == '2' || value == '3') && currentMode != 2) {

currentMode = 2; // set the current mode = 2 (For displaying LED customly)

} else if (value == '4' && currentMode != 4){

currentMode = 4; // set current mode = 2 (For displaying LED customly and run fan motor)

}

int chk = DHT.read11(DHT11\_PIN);

Serial.print("Humidity = ");

Serial.println(DHT.humidity); //Display humidity from sensor

Serial.print("Temperature = ");

Serial.println(DHT.temperature); //Display temperature from sensor

if (currentMode == 1){ // the code will run automatically if currentMode is 1

if (DHT.humidity >= 50 && DHT.humidity <= 60) {

digitalWrite(pin2, HIGH); //trigger green light

digitalWrite(pin3, LOW);

digitalWrite(pin4, LOW);

      digitalWrite(INA, LOW);

      digitalWrite(INB, LOW);

} else if (DHT.humidity >= 61 && DHT.humidity <= 70) {

      digitalWrite(pin2, LOW);

      digitalWrite(pin3, HIGH); //trigger yellow light

      digitalWrite(pin4, LOW);

      digitalWrite(INA, LOW);

      digitalWrite(INB, LOW);

} else if (DHT.humidity >= 71 || DHT.humidity <= 49) {

      digitalWrite(pin2, LOW);

      digitalWrite(pin3, LOW);

      digitalWrite(pin4, HIGH); //trigger red light

      //run Fan motor clockwise

      digitalWrite(INA, HIGH);

      digitalWrite(INB, LOW);

}

} else {

if (value == '2') {

digitalWrite(pin2, HIGH); //trigger green led

digitalWrite(pin3, LOW);

digitalWrite(pin4, LOW);

digitalWrite(INA, LOW);

digitalWrite(INB, LOW);

} else if (value == '3') {

digitalWrite(pin2, LOW);

digitalWrite(pin3, HIGH); // trigger yellow led

digitalWrite(pin4, LOW);

digitalWrite(INA, LOW);

digitalWrite(INB, LOW);

} else if (value == '4') {

digitalWrite(pin2, LOW);

digitalWrite(pin3, LOW);

digitalWrite(pin4, HIGH); //trigger red led

digitalWrite(INA, HIGH); //trigger fan motor

digitalWrite(INB, LOW);  
}

}

while (currentMode == 4) { // keep the fan run if current mode is 4

digitalWrite(INA, HIGH);

digitalWrite(INB, LOW);

}

Serial.print("CurrentMode = ");

Serial.println(currentMode); //print current mode for debugging.

delay(2000); // delay 2s

}

Explanation of Python code for web:

import serial

import MySQLdb

from flask import Flask, render\_template

app = Flask(\_\_name\_\_)

sensors = { # Dictionary with the sensors

    1 : {'name' : 'Humidity', 'state' : 0 },

    2 : {'name' : 'Temperature', 'state' : 0 },

}

database = { # Dictionary with the database

    1 : {'name' : 'Database', 'state' : 0 },

    2 : [],

}

def read\_sensor\_data(): # Update the sensor data

    global sensors # Access the global variable sensors

    global database # Access the global variable database

    sensor = ser.readline() # Read the data from the Arduino

    print(sensor)

    sensor\_str = sensor.decode('utf-8')  # Decode the bytes to a string

    for line\_sensor in sensor\_str.split('\n'): # Split the string into lines

        if line\_sensor.startswith('Humidity'): # Check if the line starts with Humidity

            sensors[1]['state'] = float(line\_sensor.split('=')[1].strip()) # Get the value after the =

        elif line\_sensor.startswith('Temperature'): # Check if the line starts with Temperature

            sensors[2]['state'] = float(line\_sensor.split('=')[1].strip()) # Get the value after the =

def connect\_to\_database():

    try:

        return MySQLdb.connect("localhost", "pi", "", "sensor\_data")

    except Exception as e:

        ser.write(b"4")  # write serial input for Arduino code to trigger red light

        print(f"Error connecting to the database: {e}")

        return None

# Main function when accessing the website

@app.route("/") # This is the main page

def index(): # This function will be executed when the main page is accessed

    read\_sensor\_data() # Update the sensor data

    # TODO: Read the status of the pins ON/OFF and update dictionary

    # This data will be sent to index.html (pins dictionary)

    templateData = { 'sensors' : sensors, 'database' :database } # Create a dictionary with the data to be sent

    # Pass the template data into the template index.html and return it

    return render\_template('index.html', \*\*templateData) # Return the template

# Function with buttons to toggle to store the data into the database or not

@app.route("/<toggleDatabase>")

def toggle\_store\_data(toggleDatabase): # This function will be executed when the main page is accessed

    read\_sensor\_data() # Update the sensor data

    dbConn = None

    try:

        dbConn = connect\_to\_database() # Connect to the database

        if dbConn:

            cursor = dbConn.cursor() # Create a cursor

            if toggleDatabase == "storeData": # Check if the button is storeData

                database[1]['state'] = 1 # Turn on the database

                ser.write(b"2") # write serial input for Arduino code to trigger green light

                # Insert the data into the database

                cursor.execute("INSERT INTO sensor\_data (humidity, temperature) VALUES (%s, %s)",

                               (str(sensors[1]['state']), str(sensors[2]['state'])))

                dbConn.commit() # Commit the changes

                print("Data stored in the database") # Print a message

                cursor.execute("SELECT \* FROM sensor\_data ORDER BY dataID DESC LIMIT 10") # Get the last 10 data

                rows = cursor.fetchall() # Fetch the rows

                for row in rows: # Loop through the rows

                    database[2].append({'humidity': row[1], 'temperature': row[2], 'time\_stamp': row[3]}) # Append the data to the database

            elif toggleDatabase == "noStoreData": # Check if the button is noStoreData

                database[1]['state'] = 0 # Turn off the database

                ser.write(b"3") # write serial input for Arduino code to trigger red light

            elif toggleDatabase == "getDatabase":  # Check if the button is getDatabase

                cursor.execute("SELECT \* FROM sensor\_data ORDER BY dataID DESC LIMIT 10") # Get the last 10 data

                rows = cursor.fetchall()

                for row in rows:

                    database[2].append({'humidity': row[1], 'temperature': row[2], 'time\_stamp': row[3]})

    finally:

        while len(database[2]) > 10: # Check if the database is greater than 10

            database[2].pop(0) # Remove the first element

        if dbConn: # Close the database

            dbConn.close()

    templateData = { 'sensors' : sensors, 'database' : database } # Create a dictionary with the data to be sent

    return render\_template('index.html', \*\*templateData) # Return the template

@app.route("/automatically") #URL/automatically

def automatic():

    read\_sensor\_data() # Update the sensor data

    ser.write(b"1") #write serial input for Arduino code to trigger automatic code

    templateData = { 'sensors' : sensors, 'database' : database }

    return render\_template('index.html', \*\*templateData)

#get data directly from arduino and send to the website

@app.route("/getData") #URL/getData

def getData():

    read\_sensor\_data() # Update the sensor data

    templateData = { 'sensors' : sensors, 'database' : database } # Create a dictionary with the data to be sent

    return render\_template('index.html', \*\*templateData) # Return the template

# Main function when accessing the website

if \_\_name\_\_ == '\_\_main\_\_':

    ser = serial.Serial('/dev/ttyUSB0', 9600, timeout = 1) # Establish the connection on a specific port

    ser.flush() # Clear the serial buffer

    app.run(host='0.0.0.0', port = 80, debug = True) # Run the app

Explanation of HTML code for display data:

<!DOCTYPE html>

    <head>

        <meta charset="utf-8">

        <meta name="viewport" content="width=device-width, initial-scale=1">

        <!-- Bootstrap CSS -->

        <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/css/bootstrap.min.css" rel="stylesheet">

        <script src="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/js/bootstrap.bundle.min.js"></script>

        <meta name="author" content="Thanh Minh" />

        <meta name="description" content="SWE30011 - IOT Programming" />

        <title> Arduino Web Server </title>

        <style>

            table, th, td {

                border:1px solid black;

            }

        </style>

    </head>

    <body class="container">

        <h1 class="text-center"> Arduino Web Server </h1>

        <p>

            <h2 class="my-4">

                Get the Data

            </h2>

            <!-- Display the buttons to get the data -->

            <a href="/getData" class="btn btn-info my-2">Get the current data</a>

            {% for sensor in sensors %} <!-- Loop through the sensors dictionary -->

                <p>{{sensors[sensor]['name']}}: {{sensors[sensor]['state']}}</p>

            {% endfor %}

        </p>

        <p>

            <h2>Run Automatically</h2>

            <p>

                Note: Database won't be stored if it is automatically run

            </p>

            <a href="/automatically" class="btn btn-success">Run Automatically</a> <!-- Display the button to run automatically -->

        </p>

        <p>

            <!-- Display the buttons to toggle the database -->

            <h3>{{database[1]['name']}}</h3>

            {% if database[1]['state'] == 1 %} <!-- Check if the database is on or off -->

                is currently <strong>on</strong></h2>

            {% else %}

                is currently <strong>off</strong></h2>

            {% endif %}

            <br />

            <a href="/storeData" class="btn btn-primary mb-2">Store Data</a> <!-- Display the button to store data -->

            <br />

            <a href="/noStoreData" class="btn btn-secondary">No Store Data</a> <!-- Display the button to no store data -->

        </p>

        <p>

            <h2>Data from Database</h2>

            <p>

                Note: Time may not the same with your local time due to server configuration

                <br />

                Maximum display the last 10 record of data

                <br />

                You need to store the data in the database first so it can get data from database

            </p>

            <a href="/getDatabase" class="btn btn-dark mb-4">Get data from database</a> <!-- Display the button to get data from database -->

            <table class="table table-striped table-bordered">

                <th class="text-center" scope="col">Humidity</th>

                <th class="text-center" scope="col">Temperature</th>

                <th class="text-center" scope="col">Date and Time</th>

                {% for entry in database[2] %} <!-- Loop through the database dictionary -->

                <tr>

                    <td class="text-center">{{ entry['humidity'] }}</td>

                    <td class="text-center">{{ entry['temperature'] }}</td>

                    <td class="text-center">{{ entry['time\_stamp'] }}</td>

                </tr>

                {% endfor %}

            </table>

        </p>

        <p>

            <h2>All Commands</h2> <!-- Display all the buttons -->

            <ol>

                <li class="my-1"><a href="/getData" class="btn btn-info">Get the current data</a></li>

                <li class="my-1"><a href="/automatically" class="btn btn-success">Run Automatically</a></li>

                <li class="my-1"><a href="/storeData" class="btn btn-primary">Store Data</a></li>

                <li class="my-1"><a href="/noStoreData" class="btn btn-secondary">No Store Data</a></li>

                <li class="my-1"><a href="/getDatabase" class="btn btn-dark mb-4">Get data from database</a></li>

            </ol>

        </p>

    </body>

</html>

# Resources

Circuit Basics (2023). *How to Use a DHT11 Humidity Sensor on the Arduino - Ultimate Guide to the Arduino #38*. *YouTube*. Available at: https://www.youtube.com/watch?v=dJJAQxyryoQ [Accessed 25 Oct. 2023].

PLNTS.com. (2021). *Temperature and humdity*. [online] Available at: https://plnts.com/en/care/doctor/temperature-and-humidity [Accessed 28 Oct. 2023].

‌

# Appendix

1. Sketch of proposed system

A black and white computer icons

Description automatically generated

1. Block diagram for proposed system

A screenshot of a computer

Description automatically generated

1. Flow chart for how Arduino system

A screenshot of a computer screen

Description automatically generated

1. Flow chart for Python code and send request.

A screenshot of a black screen

Description automatically generated

1. Tinkercad model of proposed system

A circuit board with wires

Description automatically generated

1. Schematic view of model Tinkercad

A diagram of a circuit board

Description automatically generated

1. SQL query for creating table

CREATE TABLE sensor\_data (

dataID INT AUTO\_INCREMENT NOT NULL PRIMARY KEY,

humidity VARCHAR(1O) NOT NULL,

temperature VARCHAR(1O) NOT NULL,

time TIMESTAMP NOT NULL DEFAULT CURRENT\_TIMESTAMP ON UPDATE CURRENT\_TIMESTAMP

);

1. Side view of physical system

*A close-up of a device

Description automatically generated*

1. Front view of physical system

*A circuit board with wires and a fan

Description automatically generated*

1. Visual for getting data command

A screenshot of a computer

Description automatically generated

1. Visual for automatically run command

A white background with black and red text

Description automatically generated

1. Visual for store database command

A white background with black dots

Description automatically generated

1. Visual for not storing database command

A white background with black dots

Description automatically generated

1. Visual for displaying data from database

A screenshot of a data

Description automatically generated

1. Display data from database in edge server

A computer screen shot of a computer screen

Description automatically generated

1. Command line to run server

A screen shot of a computer

Description automatically generated

1. C++ code for Arduino

#include "dht.h"  //include library

dht DHT;

#define DHT11\_PIN 7 //set Pin 7 (LED)

int pin2 = 2; //set Pin 2 (LED)

int pin3 = 3; //set Pin 3 (LED)

int pin4 = 4; //set Pin 4 (LED)

int INA = 9; // set Pin 9(Fan motor)

int INB = 8; //set Pin 8(Fan motor)

int currentMode = 0; // default of mode is 0

void setup() {

  pinMode(pin2, OUTPUT);

  pinMode(pin3, OUTPUT);

  pinMode(pin4, OUTPUT);

  pinMode(INA, OUTPUT);

  pinMode(INB, OUTPUT);

  //Set default of Fan to low

  digitalWrite(INA, LOW);

digitalWrite(INB, LOW);

  Serial.begin(9600);

}

void loop() {

int value = Serial.read(); //Read the Serial input

if (value == '1' && currentMode != 1) { // if the Serial input is 1 and current mode is not 1

currentMode = 1; // set current mode = 1 (automatically)

} else if ((value == '2' || value == '3') && currentMode != 2) {

currentMode = 2; // set the current mode = 2 (For displaying LED customly)

} else if (value == '4' && currentMode != 4){

currentMode = 4; // set current mode = 2 (For displaying LED customly and run fan motor)

}

int chk = DHT.read11(DHT11\_PIN);

Serial.print("Humidity = ");

Serial.println(DHT.humidity); //Display humidity from sensor

Serial.print("Temperature = ");

Serial.println(DHT.temperature); //Display temperature from sensor

if (currentMode == 1){ // the code will run automatically if currentMode is 1

if (DHT.humidity >= 50 && DHT.humidity <= 60) {

digitalWrite(pin2, HIGH); //trigger green light

digitalWrite(pin3, LOW);

digitalWrite(pin4, LOW);

      digitalWrite(INA, LOW);

      digitalWrite(INB, LOW);

} else if (DHT.humidity >= 61 && DHT.humidity <= 70) {

      digitalWrite(pin2, LOW);

      digitalWrite(pin3, HIGH); //trigger yellow light

      digitalWrite(pin4, LOW);

      digitalWrite(INA, LOW);

      digitalWrite(INB, LOW);

} else if (DHT.humidity >= 71 || DHT.humidity <= 49) {

      digitalWrite(pin2, LOW);

      digitalWrite(pin3, LOW);

      digitalWrite(pin4, HIGH); //trigger red light

      //run Fan motor clockwise

      digitalWrite(INA, HIGH);

      digitalWrite(INB, LOW);

}

} else {

if (value == '2') {

digitalWrite(pin2, HIGH); //trigger green led

digitalWrite(pin3, LOW);

digitalWrite(pin4, LOW);

digitalWrite(INA, LOW);

digitalWrite(INB, LOW);

} else if (value == '3') {

digitalWrite(pin2, LOW);

digitalWrite(pin3, HIGH); // trigger yellow led

digitalWrite(pin4, LOW);

digitalWrite(INA, LOW);

digitalWrite(INB, LOW);

} else if (value == '4') {

digitalWrite(pin2, LOW);

digitalWrite(pin3, LOW);

digitalWrite(pin4, HIGH); //trigger red led

digitalWrite(INA, HIGH); //trigger fan motor

digitalWrite(INB, LOW);  
}

}

while (currentMode == 4) { // keep the fan run if current mode is 4

digitalWrite(INA, HIGH);

digitalWrite(INB, LOW);

}

Serial.print("CurrentMode = ");

Serial.println(currentMode); //print current mode for debugging.

delay(2000); // delay 2s

}

1. Python code

import serial

import MySQLdb

from flask import Flask, render\_template

app = Flask(\_\_name\_\_)

sensors = { # Dictionary with the sensors

    1 : {'name' : 'Humidity', 'state' : 0 },

    2 : {'name' : 'Temperature', 'state' : 0 },

}

database = { # Dictionary with the database

    1 : {'name' : 'Database', 'state' : 0 },

    2 : [],

}

def read\_sensor\_data(): # Update the sensor data

    global sensors # Access the global variable sensors

    global database # Access the global variable database

    sensor = ser.readline() # Read the data from the Arduino

    print(sensor)

    sensor\_str = sensor.decode('utf-8')  # Decode the bytes to a string

    for line\_sensor in sensor\_str.split('\n'): # Split the string into lines

        if line\_sensor.startswith('Humidity'): # Check if the line starts with Humidity

            sensors[1]['state'] = float(line\_sensor.split('=')[1].strip()) # Get the value after the =

        elif line\_sensor.startswith('Temperature'): # Check if the line starts with Temperature

            sensors[2]['state'] = float(line\_sensor.split('=')[1].strip()) # Get the value after the =

def connect\_to\_database():

    try:

        return MySQLdb.connect("localhost", "pi", "", "sensor\_data")

    except Exception as e:

        ser.write(b"4")  # write serial input for Arduino code to trigger red light

        print(f"Error connecting to the database: {e}")

        return None

# Main function when accessing the website

@app.route("/") # This is the main page

def index(): # This function will be executed when the main page is accessed

    read\_sensor\_data() # Update the sensor data

    # TODO: Read the status of the pins ON/OFF and update dictionary

    # This data will be sent to index.html (pins dictionary)

    templateData = { 'sensors' : sensors, 'database' :database } # Create a dictionary with the data to be sent

    # Pass the template data into the template index.html and return it

    return render\_template('index.html', \*\*templateData) # Return the template

# Function with buttons to toggle to store the data into the database or not

@app.route("/<toggleDatabase>")

def toggle\_store\_data(toggleDatabase): # This function will be executed when the main page is accessed

    read\_sensor\_data() # Update the sensor data

    dbConn = None

    try:

        dbConn = connect\_to\_database() # Connect to the database

        if dbConn:

            cursor = dbConn.cursor() # Create a cursor

            if toggleDatabase == "storeData": # Check if the button is storeData

                database[1]['state'] = 1 # Turn on the database

                ser.write(b"2") # write serial input for Arduino code to trigger green light

                # Insert the data into the database

                cursor.execute("INSERT INTO sensor\_data (humidity, temperature) VALUES (%s, %s)",

                               (str(sensors[1]['state']), str(sensors[2]['state'])))

                dbConn.commit() # Commit the changes

                print("Data stored in the database") # Print a message

                cursor.execute("SELECT \* FROM sensor\_data ORDER BY dataID DESC LIMIT 10") # Get the last 10 data

                rows = cursor.fetchall() # Fetch the rows

                for row in rows: # Loop through the rows

                    database[2].append({'humidity': row[1], 'temperature': row[2], 'time\_stamp': row[3]}) # Append the data to the database

            elif toggleDatabase == "noStoreData": # Check if the button is noStoreData

                database[1]['state'] = 0 # Turn off the database

                ser.write(b"3") # write serial input for Arduino code to trigger red light

            elif toggleDatabase == "getDatabase":  # Check if the button is getDatabase

                cursor.execute("SELECT \* FROM sensor\_data ORDER BY dataID DESC LIMIT 10") # Get the last 10 data

                rows = cursor.fetchall()

                for row in rows:

                    database[2].append({'humidity': row[1], 'temperature': row[2], 'time\_stamp': row[3]})

    finally:

        while len(database[2]) > 10: # Check if the database is greater than 10

            database[2].pop(0) # Remove the first element

        if dbConn: # Close the database

            dbConn.close()

    templateData = { 'sensors' : sensors, 'database' : database } # Create a dictionary with the data to be sent

    return render\_template('index.html', \*\*templateData) # Return the template

@app.route("/automatically") #URL/automatically

def automatic():

    read\_sensor\_data() # Update the sensor data

    ser.write(b"1") #write serial input for Arduino code to trigger automatic code

    templateData = { 'sensors' : sensors, 'database' : database }

    return render\_template('index.html', \*\*templateData)

#get data directly from arduino and send to the website

@app.route("/getData") #URL/getData

def getData():

    read\_sensor\_data() # Update the sensor data

    templateData = { 'sensors' : sensors, 'database' : database } # Create a dictionary with the data to be sent

    return render\_template('index.html', \*\*templateData) # Return the template

# Main function when accessing the website

if \_\_name\_\_ == '\_\_main\_\_':

    ser = serial.Serial('/dev/ttyUSB0', 9600, timeout = 1) # Establish the connection on a specific port

    ser.flush() # Clear the serial buffer

    app.run(host='0.0.0.0', port = 80, debug = True) # Run the app

1. HTML code

<!DOCTYPE html>

    <head>

        <meta charset="utf-8">

        <meta name="viewport" content="width=device-width, initial-scale=1">

        <!-- Bootstrap CSS -->

        <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/css/bootstrap.min.css" rel="stylesheet">

        <script src="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/js/bootstrap.bundle.min.js"></script>

        <meta name="author" content="Thanh Minh" />

        <meta name="description" content="SWE30011 - IOT Programming" />

        <title> Arduino Web Server </title>

        <style>

            table, th, td {

                border:1px solid black;

            }

        </style>

    </head>

    <body class="container">

        <h1 class="text-center"> Arduino Web Server </h1>

        <p>

            <h2 class="my-4">

                Get the Data

            </h2>

            <!-- Display the buttons to get the data -->

            <a href="/getData" class="btn btn-info my-2">Get the current data</a>

            {% for sensor in sensors %} <!-- Loop through the sensors dictionary -->

                <p>{{sensors[sensor]['name']}}: {{sensors[sensor]['state']}}</p>

            {% endfor %}

        </p>

        <p>

            <h2>Run Automatically</h2>

            <p>

                Note: Database won't be stored if it is automatically run

            </p>

            <a href="/automatically" class="btn btn-success">Run Automatically</a> <!-- Display the button to run automatically -->

        </p>

        <p>

            <!-- Display the buttons to toggle the database -->

            <h3>{{database[1]['name']}}</h3>

            {% if database[1]['state'] == 1 %} <!-- Check if the database is on or off -->

                is currently <strong>on</strong></h2>

            {% else %}

                is currently <strong>off</strong></h2>

            {% endif %}

            <br />

            <a href="/storeData" class="btn btn-primary mb-2">Store Data</a> <!-- Display the button to store data -->

            <br />

            <a href="/noStoreData" class="btn btn-secondary">No Store Data</a> <!-- Display the button to no store data -->

        </p>

        <p>

            <h2>Data from Database</h2>

            <p>

                Note: Time may not the same with your local time due to server configuration

                <br />

                Maximum display the last 10 record of data

                <br />

                You need to store the data in the database first so it can get data from database

            </p>

            <a href="/getDatabase" class="btn btn-dark mb-4">Get data from database</a> <!-- Display the button to get data from database -->

            <table class="table table-striped table-bordered">

                <th class="text-center" scope="col">Humidity</th>

                <th class="text-center" scope="col">Temperature</th>

                <th class="text-center" scope="col">Date and Time</th>

                {% for entry in database[2] %} <!-- Loop through the database dictionary -->

                <tr>

                    <td class="text-center">{{ entry['humidity'] }}</td>

                    <td class="text-center">{{ entry['temperature'] }}</td>

                    <td class="text-center">{{ entry['time\_stamp'] }}</td>

                </tr>

                {% endfor %}

            </table>

        </p>

        <p>

            <h2>All Commands</h2> <!-- Display all the buttons -->

            <ol>

                <li class="my-1"><a href="/getData" class="btn btn-info">Get the current data</a></li>

                <li class="my-1"><a href="/automatically" class="btn btn-success">Run Automatically</a></li>

                <li class="my-1"><a href="/storeData" class="btn btn-primary">Store Data</a></li>

                <li class="my-1"><a href="/noStoreData" class="btn btn-secondary">No Store Data</a></li>

                <li class="my-1"><a href="/getDatabase" class="btn btn-dark mb-4">Get data from database</a></li>

            </ol>

        </p>

    </body>

</html>