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Smart Indoor Safety & Comfort Monitor

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TASK 9.1P – MULTI-SENSOR USE-CASE DESIGN & IMPLEMENTATION

SIT225 | Data Capture Technologies

1. Introduction

Indoor environments directly affect both safety and comfort. Factors such as temperature and humidity determine whether conditions are healthy or conductive to issues like mould growth, while obstacles or blocked spaces can present physical hazards. Many homes and workplaces lack affordable systems that monitor both environmental comfort and spatial safety in real time.

This project proposes a low-cost, multi-sensor IoT system using Arduino Nano 33 IoT, DHT22 temperature/humidity sensor, HC-SR04 ultrasonic distance sensor. The system collects environmental data, logs it locally via a python script, and enables visualization and interpretation. By combining these two sensing domains, the project aims to provide a practical demonstration of how IoT data can be used to inform comfort and safety decisions in indoor settings.

2. Problem Statement

Indoor environments are vulnerable to conditions that compromise human health and safety. High humidity can promote mould growth and exacerbate respiratory illness, while cluttered or obstructed pathways increase the likelihood of accidents. Current affordable solutions are fragmented, offering only partial monitoring of these issues.

The problem addressed in this project is the lack of a low-cost, integrated solution that monitors both environmental comfort and spatial safety. The project implemented a multi-sensor IoT device that continuously records temperature, humidity, and obstacle distance, logs the data for analysis, and produces visual insights that can inform corrective actions.

3. Literature Review

a. Indoor Humidity, Mould & Health

High relative humidity typically above 70-80% creates favourable conditions for mould growth in homes. While the original VTT mould model was based on surface humidity and temperature measured in laboratory conditions, applying it directly to air humidity often under predicts mould risk, since surfaces such as walls and windows can hold more moisture than the surrounding air. Humidity control is widely recommend to prevent indoor mould growth, which is associated with respiratory issues, allergies, and asthma exacerbation. The WHO's guidelines on indoor air quality emphasize that microbial growth is linked to dampness and humidity, and suggests preventing persistent dampness and controlling moistures as a key public health measure (WHO, 2009). Additionally, modelling studies show that relative humidity above about 70-80% is especially conductive to mould proliferation in domestic environments.

b. Indoor Temperature and comfort

Indoor temperature is a critical factor in determining human comfort, productivity, and well-being. Small deviations in temperature can strongly affect perceived comfort, and thus accurate measurement is vital for both research and everyday monitoring. According to Lundstrom and Mattsson (2020) the indoor air temperature measurements are prone to errors due to radiation effects from surrounding surfaces such as walls and windows. Sensors do not measure the true air temperature but rather their own body temperature, which is influenced by both convection and radiation exchange.

To mitigate these limitation, placement and shielding of the sensor become essentials. Because avoiding direct exposure to radiant heat sources, ensuring mild air circulation around the sensor, and in the some cases applying radiation shielding similar to that used in outdoor weather stations.

c. Ultrasonic Sensing & Distance Measurement.

High-frequency sound pulses are emitted by ultrasonic sensors, which then measure the duration of flight to calculate distance. For example, how long it takes for the echo to return. They are extensively utilized in robotics, proximity sensing, and obstacle avoidance in both consumer and commercial applications. Narrow beam width like limited field of view and sensitivity to object surface characteristics are drawbacks, though. The sensor has to be positioned carefully in interior safety scenarios such keeping an eye on a hallway in order to identify significant impediments.

d. Gap and Rationale for Combined Approach

While monitoring the environmental condition such as the temperature, humidity, CO2 is common in IoT literature, and ultrasonic sensors are common in robotics, fewer low-cost systems integrate comfort and spatial safety monitoring in one device. A system that monitoring environmental conditions and warns of physical obstruction offers enhanced utility. This dual-purpose integration is thus valuable for demonstrating sensor fusion at the hobbyist level.

4. Methods:

a. Hardware Used:

- Arduino Nano 33 IoT: micro-controller with WiFi and 3.3V logic.
- DHT22: Temperature and relative humidity sensor, and works with 3.3V
- HC-SR04 Ultrasonic: Distance sensor requires 5V supply, its ECHO output is stepped down via a voltage divider to 3.3V for safe microcontroller input.
- Breadboard, jumper wires.

b. Software Setup

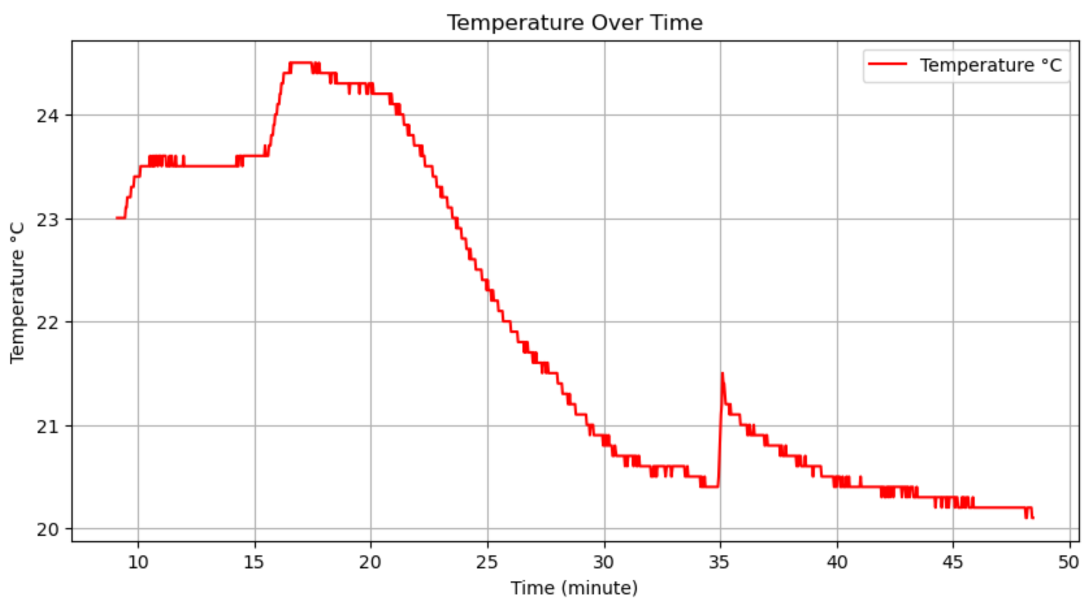
- For this prototype to work I have used the software Arduino IDE to program the component which is the DHT22 Temperature and Humidity sensor, and The Ultrasonic HC-SR04 sensor to read and collect data every 2 seconds, and print a readable csv formatted data.
- After, I closed the Arduino IDE to then create a python serial logger where it captures Arduino outputs and I let it run for about 30-50mins when running the code, the python serial logger creates a csv files where the output from the Arduino components is being stored into the csv file in real-time.
- Lastly, I used Jupyter Lab and use Pandas and Matplotlib to generate the line graphs for the 3 different data that is captured from the 2 sensors.

5. Implementation

To implement this project, first the system was assembled using the breadboard where I connect the dht22 sensor on and the ultrasonic sensor isn’t being assembled on the breadboard where I instead connect the pin directly to the Arduino Nano 33 IoT. This is due because during the data captures I wanted to move the Ultrasonic sensor to face different directions and so it captures different data and when making the graph it shows an interesting pattern. For this project prototype to work the HC-SR04 sensor is connected to the 5V pin on the Arduino while the DHT22 sensor is connected with the 3.3V. The Arduino was programmed using the IDE. The sketch used the DHT library to read temperature and humidity, while the ultrasonic distance was calculated by measuring the echo pulse duration and converting it into centimetres. The Python Serial logger script is implemented to read the Serial output from the Serial output from the Arduino and write only the CSV-formatted lines into a file called sensor_log.csv. The script opened the serial connection, filtered out unnecessary text, and appended each valid reading.

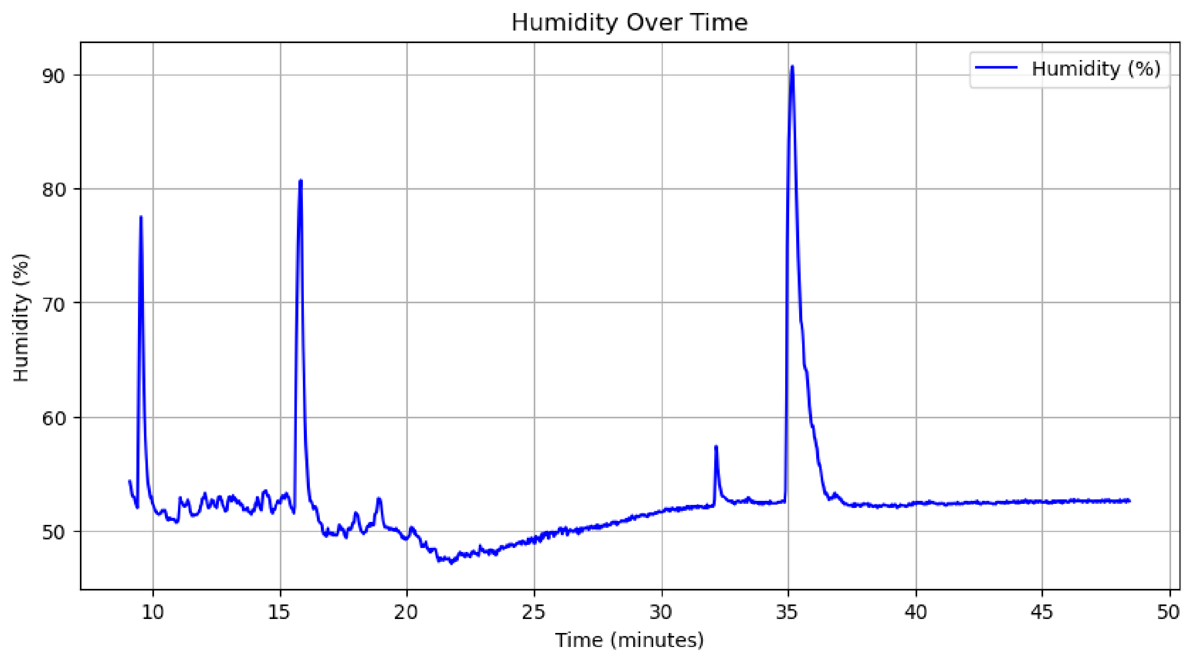
When capturing the data for the DHT22 sensor I first started out by capturing the room temperature with the electric heater on for about 10-15mins and after I turned off the heater and opened the window the door to the room so as the room temperature cools down you'll see a pattern in the graph that shows that the temperature that is being collected is decreasing. As for the Humidity data, it works like the temperature where the humidity changed however, throughout the capture I would occasionally put my finger on the sensors and as well as blow on it to see the change in the humidity percentage in the serial outputs. Lastly, when capturing the ultrasonic distance I would move around objects in front of the sensors as well making the sensors face different directions and moving the object distance from the sensors.

a. Temperature over Time graph



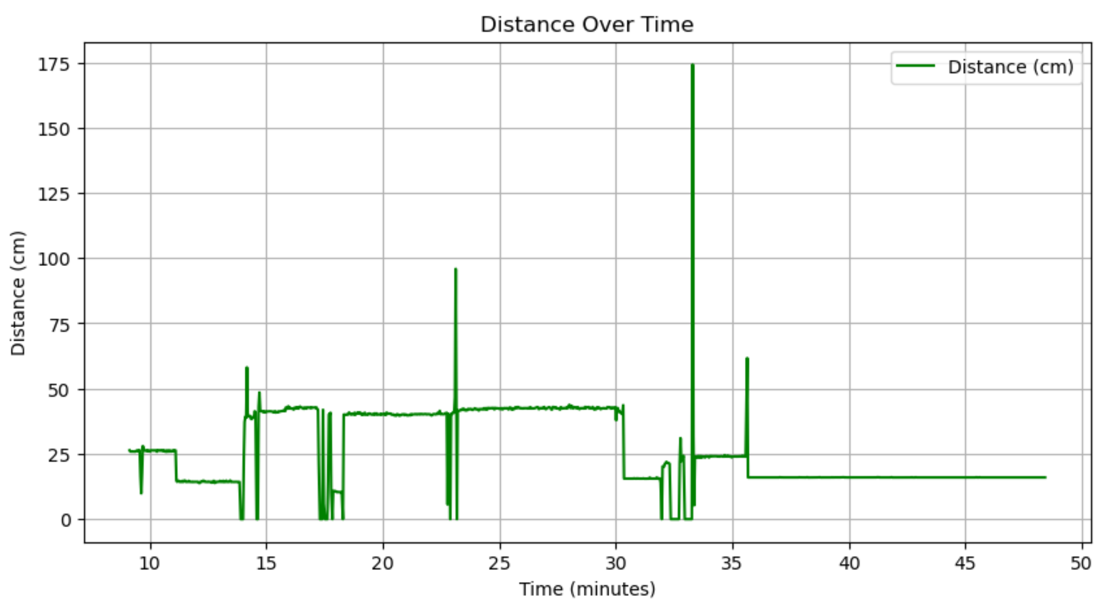
In this graph as you can see here is that when I first capture the data of the temperature it shows that we started at 23 degrees and as the heaters started to heat up the room we can see a rise in the line graph and later on you can see that the temperature is decreasing and this is due to the heater being turned off then the room temperature is also decreasing and once the window and the door open you can see a huge decrease in temperature. That one fluctuations in the 35min time span could be due to when I wanted to collect the data by blowing on the sensor.

b. Humidity over Time graph



The humidity sensors would usually remain steady however, the big spike in fluctuation in the graph is due to me holding and placing my hand on the sensors so the humidity would increases. And when it decrease because it's due me releasing it and the sensor and let it capture the humidity level naturally and I steady changes in the humidity level would also be affected from me opening the windows and letting cold air enter the room.

c. Distance measurement from ultrasonic sensor over time



In this graph you can see that there are a lot more changes in the graph this because as its recording and collecting the data I would move the sensors around a lot as well as the object in front of it. As you can see from the big spike all the way to 175 it's because as I was moving around the sensor it probably captures the data of the ceilings and when the distances get to zero this is due to my hand or the object being too close to the sensor so it doesn't capture any data. Lastly, for the steady data at the end was when I stopped moving the sensor and objects.

6. Plan and budgeting

Components	Costs(AUD)	Vendor

Arduino Nano 33 IoT	$40	Pakronics
DHT22	$21	Altronics
HC-SR04	$10	Jaycar
Breadboard + wires	$17	Amazon + Jaycar
Total	$88	

The Planning Process

	Gantt Chart			
Process	**Week 9**	**Week 10**	**Week 11**	**Week 12**
Planning				
Hardware aseembly				
Arduino Sketch + Python logging				
Data Collection				
Data Analysis and graph				
Report + presentation				

7. Discussion

For this prototype there are some strengths and limitations so for this prototype or concept is that this is low-costs and it's a simple and replicable systems. The combines comfort and safety in one framework where it gives the user the idea of how comfortability can affect living condition and their productivity. The limitation is that the ultrasonics sensor detects only directions which is why I have to move it around to face it in different directions. The DHT22 refresh rate is slow. Lastly, the it's short monitoring sessions so the long-term data is needed for robust analysis.

8. Conclusion

This project demonstrates a functional IoT systems integrating a DHT22 and HC-SR04 with an Arduino Nano 33 IoT. The system successfully monitors indoor comfort and safety like obstacle detection in a unified framework. The results show clear, interpretable patterns, validating the system's ability to capture meaningful data. Although limited by single-direction sensing and short data collection periods the project establishes a strong foundation for future enhancements, including cloud integration and expanded sensor sets.

References

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Video Link:

Demonstration video:

https://youtu.be/u2ralNFLaNw

Presentation video:

https://youtu.be/El-N554WCZw

Github Link:

https://github.com/PanhaAth/SIT225_2025-T2/tree/main/Week%209