Design and Analysis of an Air Quality Monitoring System

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Research:

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UMASS LOWELL

Motivation and Objective:

Air Monitoring Design Motivation:

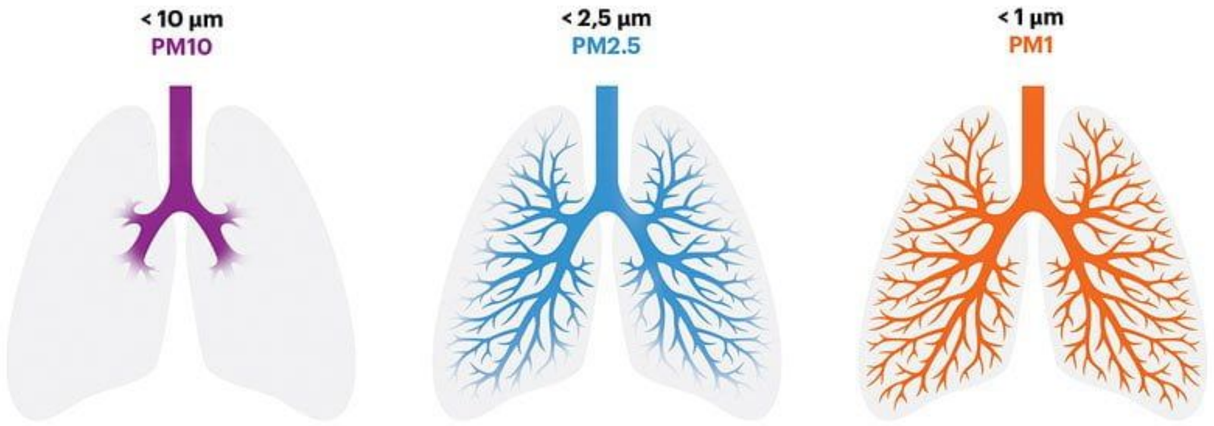


Figure 1

- Respiratory + cardiovascular disease + cancer variants
- CARB-initiated Children's Health Study Children 18 yrs of age and PM2.5[1]

Air Monitoring Design Objective:

To be aware of Particulate Matter in the air

1. Analyze long term variations with commercial EPA system
2. Compare EPA system with a lab built monitoring system using Adafruit microcontrollers and a Plantower sensor
3. Evaluate sensitivity of both systems to aerosol detection

[1]Andell, Henri. "Fine Particles PM2.5 Have Significant Impact on Health." Safera, 6 Apr. 2024, www.safera.com/fine-particles-pm25-are-significant-health-risk/.

Analyzing Air Quality Systems: PurpleAir

$$PM_{2.5} = 2.5\mu m = 2.5\ x\ 10^{-6}\ microns\ diameter$$

- Plantower Sensor PMS5003 data/objective to be aware of $PM_{2.5}$
- Collected data Every 10 minutes using 2 PMS5003 sensors

PURPLEAIR:

- Fan >> reflections from particles (count) >> electric signal filter

Figure 1:Plantower PMS5003 sensor

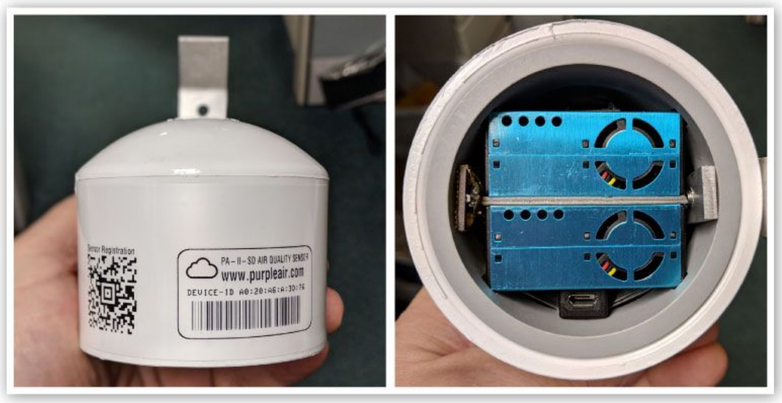


Figure 2: Plantower PMS5003 sensor Specs

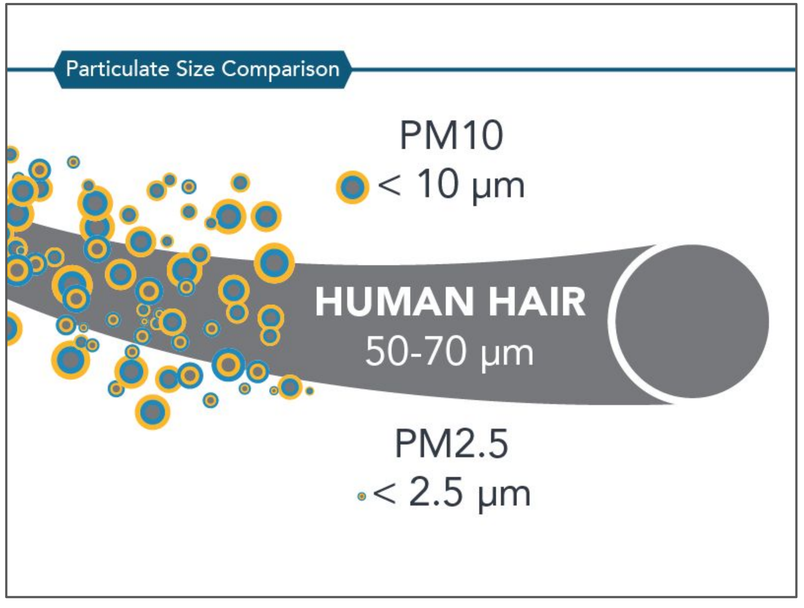
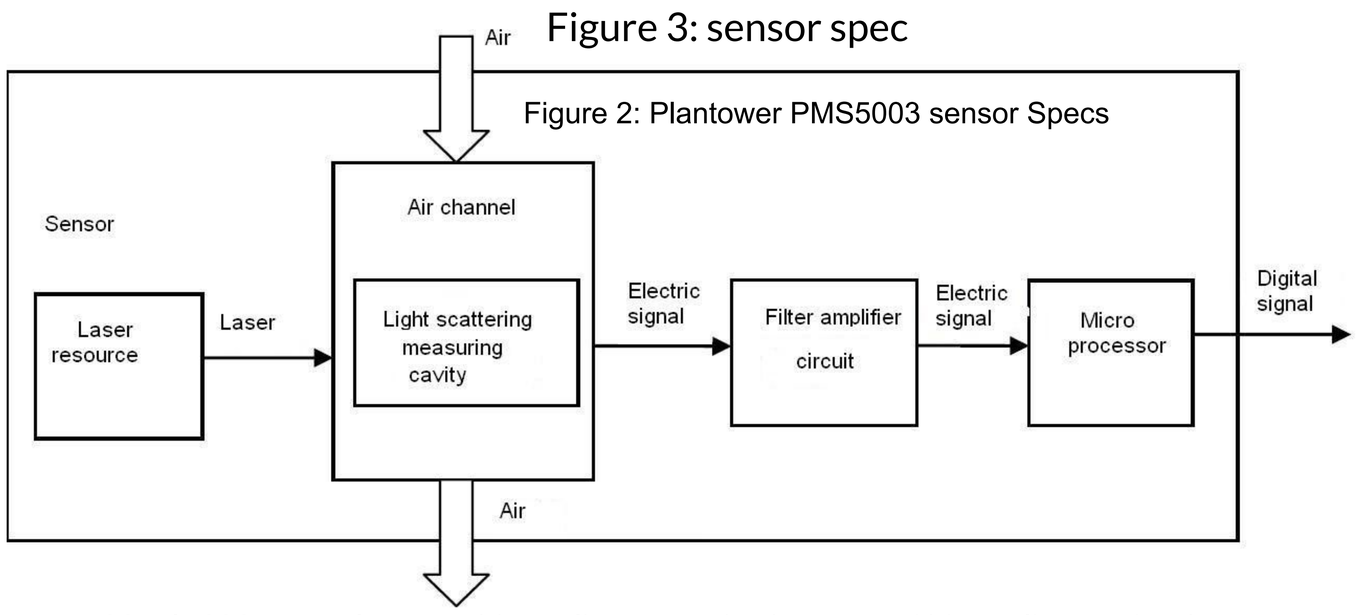


Figure 3: sensor spec



[1]1Knudsen, Travis. “Air Quality Monitor.” Lane Regional Air Protection Agency, 23 July 2024, www.lrapa.org/air-quality-protection/current-aqi/air-quality-monitor/.

[2]California Air Resources Board.” Inhalable Particulate Matter and Health (PM2.5 and PM10) | California Air Resources Board, ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health#:~:text=Long%2Dterm%20(months%20to%20years,lung%20function%20growth%20in%20children. Accessed 4 Sept. 2024.

[3]“Air Quality Monitor (PM 2.5, Temperature & Humidity Sensor).” DFRobot, www.dfrobot.com/product-1612.html. Accessed 3 Sept. 2024.

Experiment I: PurpleAir

PurpleAir

Figure 1[1]

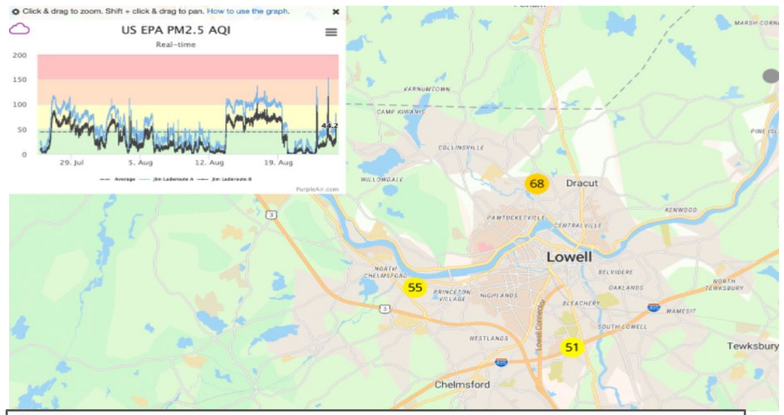


Figure 1.a

```
import requests
from datetime import datetime
from datetime import datetime, timedelta
import copy
import matplotlib.pyplot as plt
import matplotlib.dates as mdates
import pytz


#api_key = "06BD1404-4AB5-11EF-95CB-42010A80000E"
api_key = "55F96924-50D6-11EF-95CB-42010A80000E"

sensor_index = '230763'  # Replace with your sensor index

#UTC
start_ts = 1719940800 #Jul 2, 2024, 5:20:00 PM [0]
end_ts = 1722360000 #Jul 30, 2024, 5:20:00 PM

fields = 'pm2.5_alt,pm2.5_atm'

url = f"https://api.purpleair.com/v1/sensors/{sensor_index}/history?start_timest
print(url)

params = {
    'sensor_index': sensor_index,
    'fields': fields,
}

headers = {
    'Content-Type': 'application/json',
    'X-API-KEY': api_key
}

r = requests.get(url,headers=headers,params=params)
```

```
https://api.purpleair.com/v1/sensors/230763/history?start_ti
<class 'int'>
['Jul 02 2024, 05:20:00 PM', 3.6, 4.970000000000001]
['Jul 02 2024, 05:30:00 PM', 3.7, 5.27]
['Jul 02 2024, 05:40:00 PM', 3.8, 5.368]
['Jul 02 2024, 05:50:00 PM', 3.6, 5.18]
['Jul 02 2024, 06:00:00 PM', 3.8, 5.41]
['Jul 02 2024, 06:10:00 PM', 4.0, 5.8225]
['Jul 02 2024, 06:20:00 PM', 4.0, 5.9315]
['Jul 02 2024, 06:30:00 PM', 4.1, 5.955]
['Jul 02 2024, 06:40:00 PM', 4.2, 5.914]
['Jul 02 2024, 06:50:00 PM', 4.3, 6.218]
['Jul 02 2024, 07:00:00 PM', 4.2, 6.4335]
```

Figure 1:July 5 at 7:30PM to July 30 at 5:10P

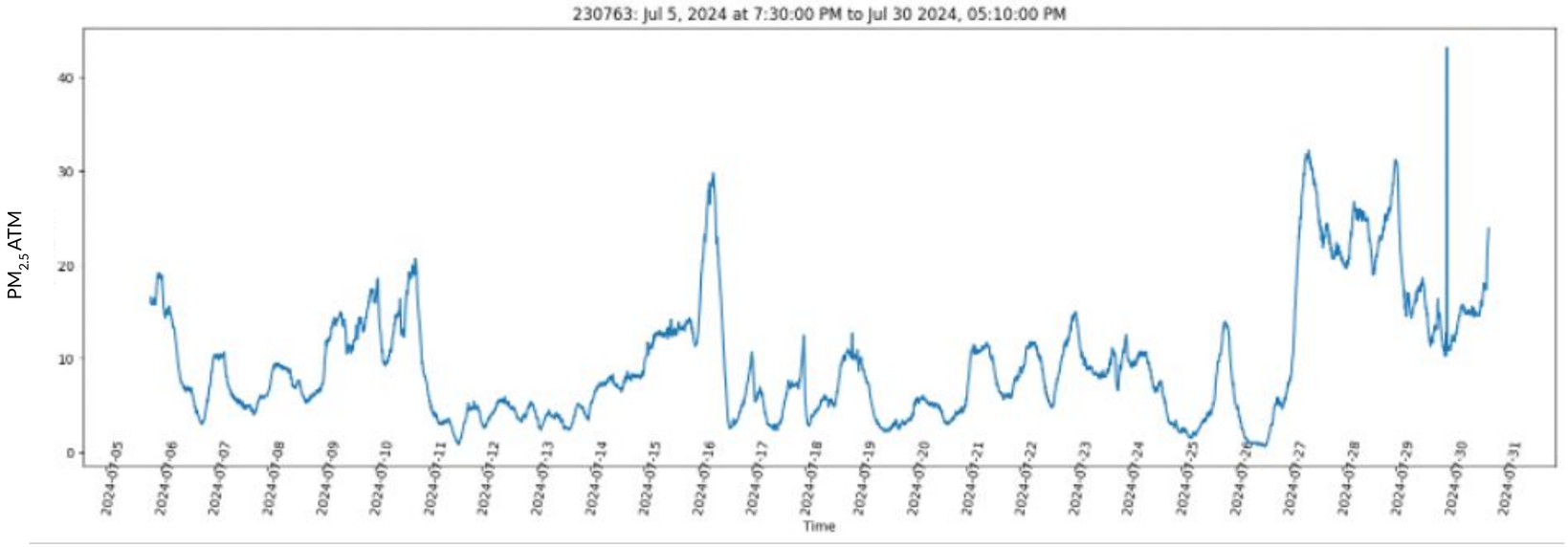
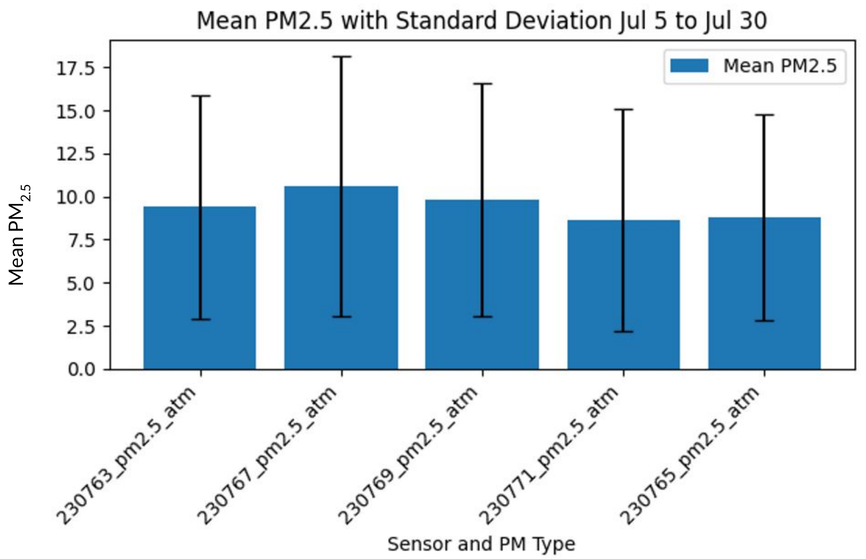


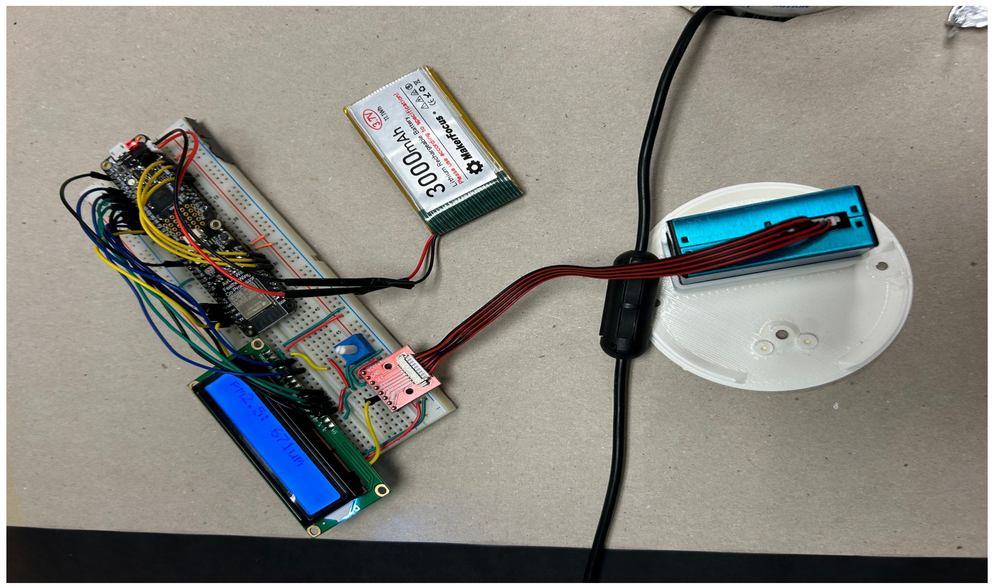
Figure 2: Mean and standard deviation for 5 sensors



[1]"Real-Time Air Quality Map." *PurpleAir*, map.purpleair.com/1/mAQI/a10/p604800/cC0#11/42.6481/-71.3343. Accessed 3 Sept. 2024.

Experiment II: Lab built system with Adafruit devices

Figure 1: Adafruit & Plantower Sensor



Every 10 seconds using a single PMS5003 sensor

Air-Quality Monitor System Design:

M4 feather Express & Adafruit Airlift powered by a battery to collect data wirelessly

Adafruit microcontroller, Plantower PMS5003 sensor, WIFI

Figure 2: Retrieving Data on Dashboard

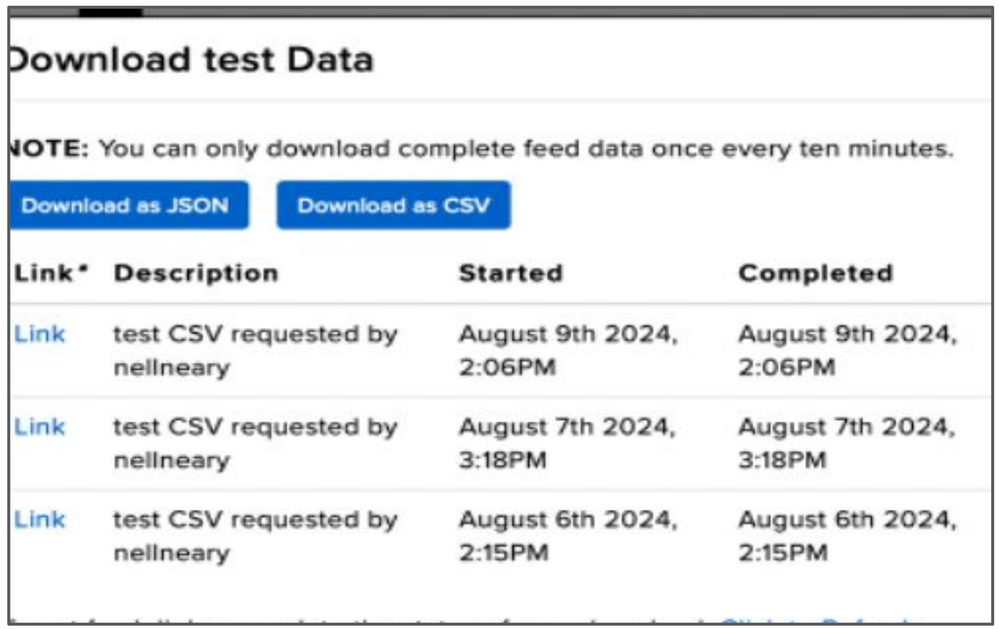


Figure 3: Data Results

```
[ ] #REAL TIME DATA FROM ADAFRUIT
    from google.colab import files

    uploaded = files.upload()

    import pandas as pd
    import io

    # Get the actual filename from the uploaded dictionary
    filename = list(uploaded.keys())[0]  # Assuming you uploaded only one file

    df = pd.read_csv(io.BytesIO(uploaded[filename]))
    pd.set_option("display.max_rows", None)


    print(df[['value','created_at']])
```

```
Choose Files  no files selected    Upload widget is only available when the cell has been executed in
cell to enable.
Saving adafruit_aug6.csv to adafruit_aug6 (13).csv
     value                created_at
0        0  2024-08-06 15:20:48 UTC
1        0  2024-08-06 15:20:57 UTC
2        0  2024-08-06 15:21:07 UTC
3        0  2024-08-06 15:21:17 UTC
4        0  2024-08-06 15:21:27 UTC
5        0  2024-08-06 15:21:36 UTC
```

(Contd.) Experiment II Aerosol Detection:

- Lit candles in the tank blown out 11:50AM, top was covered and left for an hour.
- Sensors given a 15 minute break
- Candles relit and blown out at 1:05PM and left for another hour

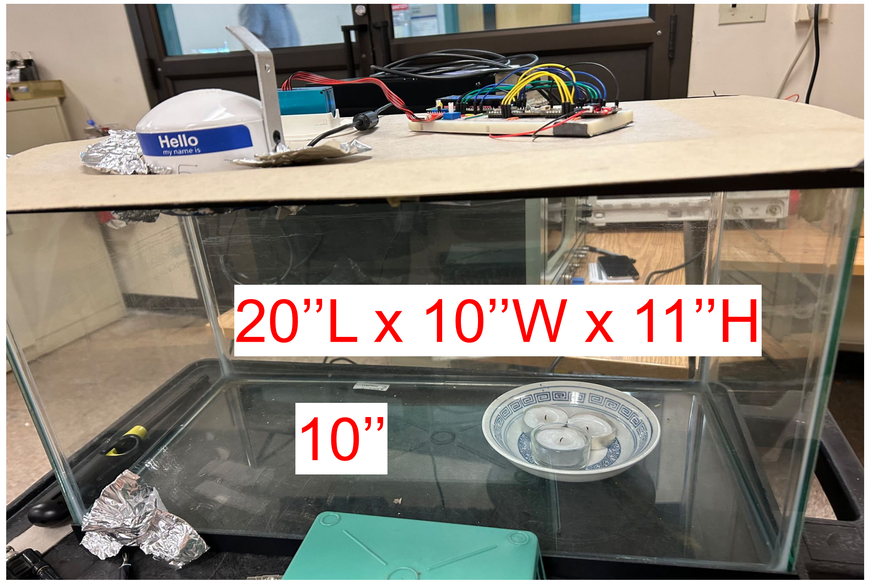
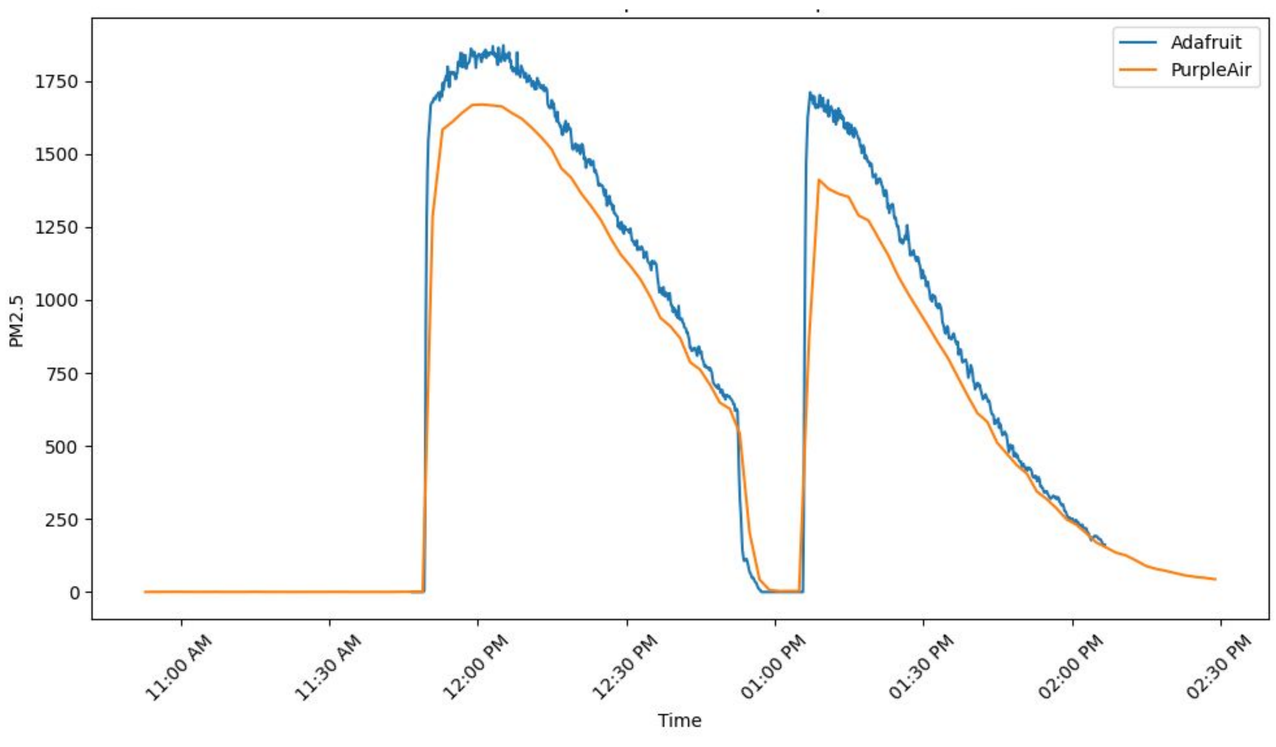


Figure 1

Results: Data collection

Figure 2:



Accuracy:

- Approximate 2,000 $PM_{2.5}$ value difference during their max peaks
- Trend in particulate variation over time is accurately captured by lab-built sensing system
- Commercial system 2 Plantower sensors that average $PM_{2.5}$

Results

- Experiment I: Single sensor graph data for 25 days showed $PM_{2.5}$ fluctuations. Comparing all five indoor PurpleAir monitors' mean and standard deviation data were consistent
- Experiment II: Adafruit and PurpleAir air monitoring systems showed comparative sensitivity to aerosol detection

$PM_{2.5}$ levels in the air increase when exposed to a large volume of aerosol particles in an area

The smaller the particle, the more difficult it is to locate and prevent harm