Using Machine Learning for IoT

Meet the Team

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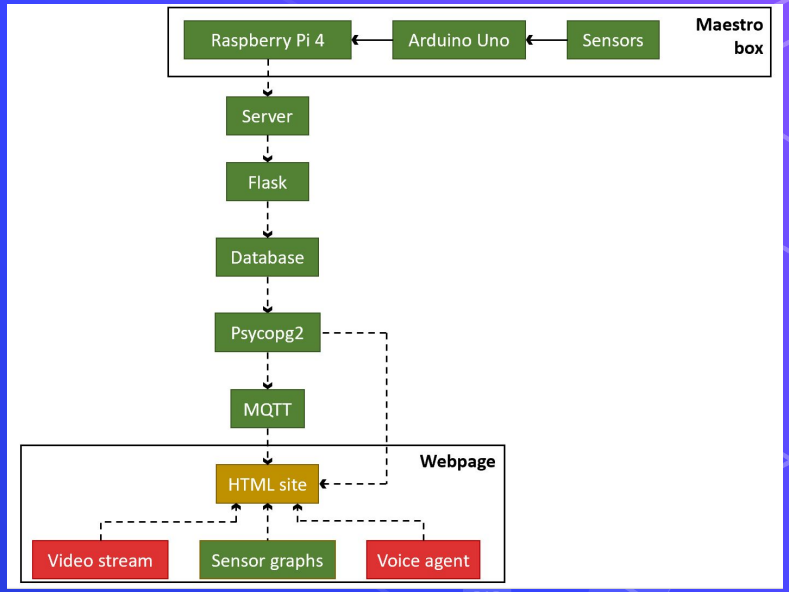
Motivation

Smart applications in healthcare and energy

- Reduce energy consumption in buildings
  - Considering occupancy and comfort preferences to automate HVAC system
- Monitoring health of elderly
  - Identify actions and location

Objective

- Using ambient sensing to infer human activity
- Visual representation of data being collected through webpage
  - Observe trends by looking at signatures

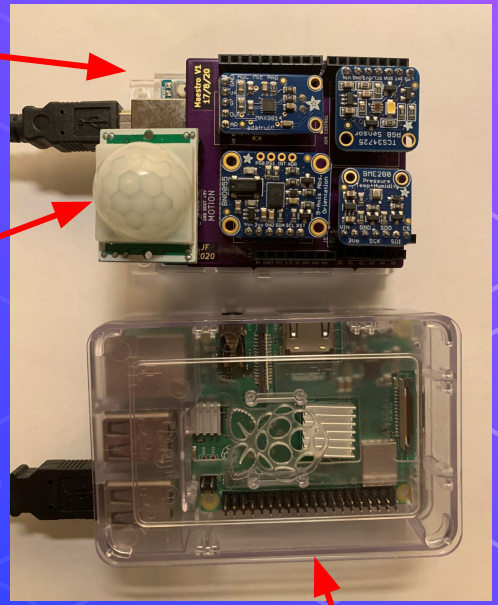


Background

- Ambient sensing - detecting human presence using sensors which measure characteristics in surroundings
- Raspberry pi - small integrated circuit which supports functionalities of a computer
- Arduino - board with input/output pins
- Database - organized collection of structured information

Maestro Box

- Hardware component of system
- Two modules
  - Sensing node - external sensors measuring PIR, color and illumination, audio, pressure, humidity, temperature, IMU attached to Arduino Uno
  - Raspberry Pi
- 9 sensors, 18 data points per unit time
- Collects data at 30 samples/sec



Smartbox Database

- Postgres database updated with data from sensors every 10 seconds
- Hosted on server
- Used to store and retrieve data
  - SQL to query data
- Psycopg2, python library, to read from smartbox
- TimescaleDB to support timestamps

Two complete sets of data from two timestamps stored in the old table format

18 rows per instance of time

```
smartbox=# select * from temp where label='Walking' or label='Running';
 box_name |   channel_name   |          time          |  value   |  label
----------+------------------+------------------------+----------+---------
 Box12    | PIR              | 2021-07-29 21:45:00-04 |        1 | Walking
 Box12    | Audio            | 2021-07-29 21:45:00-04 |    1.533 | Walking
 Box12    | Color Temp (K)   | 2021-07-29 21:45:00-04 |     3468 | Walking
 Box12    | Lumosity         | 2021-07-29 21:45:00-04 |      217 | Walking
 Box12    | R                | 2021-07-29 21:45:00-04 |      694 | Walking
 Box12    | G                | 2021-07-29 21:45:00-04 |      464 | Walking
 Box12    | B                | 2021-07-29 21:45:00-04 |      395 | Walking
 Box12    | C                | 2021-07-29 21:45:00-04 |     1503 | Walking
 Box12    | Temperature      | 2021-07-29 21:45:00-04 |    24.84 | Walking
 Box12    | Pressure         | 2021-07-29 21:45:00-04 | 1011.285 | Walking
 Box12    | Approx. Altitude | 2021-07-29 21:45:00-04 |   16.377 | Walking
 Box12    | Humidity         | 2021-07-29 21:45:00-04 |   74.181 | Walking
 Box12    | Accel X          | 2021-07-29 21:45:00-04 |     0.09 | Walking
 Box12    | Accel Y          | 2021-07-29 21:45:00-04 |     -1.4 | Walking
 Box12    | Accel Z          | 2021-07-29 21:45:00-04 |     9.83 | Walking
 Box12    | Magnet X         | 2021-07-29 21:45:00-04 |   12.375 | Walking
 Box12    | Magnet Y         | 2021-07-29 21:45:00-04 |    7.063 | Walking
 Box12    | Magnet Z         | 2021-07-29 21:45:00-04 |    8.432 | Walking
 Box12    | PIR              | 2021-07-29 21:52:00-04 |        0 | Running
 Box12    | Audio            | 2021-07-29 21:52:00-04 |    1.234 | Running
 Box12    | Color Temp (K)   | 2021-07-29 21:52:00-04 |     5724 | Running
 Box12    | Lumosity         | 2021-07-29 21:52:00-04 |      321 | Running
 Box12    | R                | 2021-07-29 21:52:00-04 |      794 | Running
 Box12    | G                | 2021-07-29 21:52:00-04 |      455 | Running
 Box12    | B                | 2021-07-29 21:52:00-04 |      345 | Running
 Box12    | C                | 2021-07-29 21:52:00-04 |     1303 | Running
 Box12    | Temperature      | 2021-07-29 21:52:00-04 |    25.48 | Running
 Box12    | Pressure         | 2021-07-29 21:52:00-04 | 1031.345 | Running
 Box12    | Approx. Altitude | 2021-07-29 21:52:00-04 |   18.377 | Running
 Box12    | Humidity         | 2021-07-29 21:52:00-04 |   75.181 | Running
 Box12    | Accel X          | 2021-07-29 21:52:00-04 |     0.19 | Running
 Box12    | Accel Y          | 2021-07-29 21:52:00-04 |     -1.5 | Running
 Box12    | Accel Z          | 2021-07-29 21:52:00-04 |     9.35 | Running
 Box12    | Magnet X         | 2021-07-29 21:52:00-04 |   13.375 | Running
 Box12    | Magnet Y         | 2021-07-29 21:52:00-04 |    7.453 | Running
 Box12    | Magnet Z         | 2021-07-29 21:52:00-04 |    8.232 | Running
(36 rows)
```

Modified structure for Data table with only one row per data sample

```
 box_name |        time         | PIR | audio | color_temp | lumosity | R | G | B | C | temperature | pressure | approx_altitude | humidity | accel_x | accel_y | accel_z | magnet_x | magnet_y | magnet_z |  label
----------+---------------------+-----+-------+------------+----------+---+---+---+---+-------------+----------+-----------------+----------+---------+---------+---------+----------+----------+----------+---------
 Box12    | 2021-07-29 21:45:00-04 |   1 | 1.533 |       3468 |      217 | 694 | 464 | 395 | 1503 |       24.84 | 1011.285 |          16.377 |   74.181 |    0.09 |    -1.4 |    9.83 |   12.375 |    7.063 |    8.432 | Walking
 Box12    | 2021-07-29 21:52:00-04 |   0 | 1.234 |       5724 |      321 | 794 | 455 | 345 | 1303 |       25.48 | 1031.345 |          18.377 |   75.181 |    0.19 |    -1.5 |    9.35 |   13.375 |    7.453 |    8.232 | Running
(2 rows)
```

```
(pai_mqtt) ambisense@ortiz-lambda-quad:~$ python3 get_sensor_data_from_db_new.py
Connecting to broker  test.mosquitto.org
connected OK
Data:1 PIR 2021-08-03 20:58:48.243562-04:00 0.0 Publishing:maestro/pir 2021-08-03 20:58:48.243562-04:00 0.0
Data:1 Audio 2021-08-03 20:58:48.243562-04:00 0.151|Publishing:maestro/audio 0.151
Data:1 Color Temp (K) 2021-08-03 20:58:48.243562-04:00 5836.0|Publishing:maestro/color temp 5836.0
Data:1 Lumosity 2021-08-03 20:58:48.243562-04:00 118.0|Publishing:maestro/lumosity 118.0
Data:1 R 2021-08-03 20:58:48.243562-04:00 138.0|Publishing:maestro/r 138.0
Data:1 G 2021-08-03 20:58:48.243562-04:00 178.0|Publishing:maestro/g 178.0
Data:1 B 2021-08-03 20:58:48.243562-04:00 161.0|Publishing:maestro/b 161.0
Data:1 C 2021-08-03 20:58:48.243562-04:00 500.0|Publishing:maestro/c 500.0
Data:1 Temperature 2021-08-03 20:58:48.243562-04:00 26.62|Publishing:maestro/temp 26.62
Data:1 Pressure 2021-08-03 20:58:48.243562-04:00 1015.43|Publishing:maestro/press 1015.43
Data:1 Approx. Altitude 2021-08-03 20:58:48.243562-04:00 -18.131|Publishing:maestro/alt -18.131
Data:1 Humidity 2021-08-03 20:58:48.243562-04:00 45.91|Publishing:maestro/humid 45.91
Data:1 Accel X 2021-08-03 20:58:48.243562-04:00 -0.36|Publishing:maestro/accel-x -0.36
Data:1 Accel Y 2021-08-03 20:58:48.243562-04:00 -0.44|Publishing:maestro/accel-y -0.44
Data:1 Accel Z 2021-08-03 20:58:48.243562-04:00 9.5|Publishing:maestro/accel-z 9.5
Data:1 Magnet X 2021-08-03 20:58:48.243562-04:00 -0.688|Publishing:maestro/magnet-x -0.688
Data:1 Magnet Y 2021-08-03 20:58:48.243562-04:00 35.0|Publishing:maestro/magnet-y 35.0
Data:1 Magnet Z 2021-08-03 20:58:48.243562-04:00 -90.5|Publishing:maestro/magnet-z -90.5
Data:2 PIR 2021-08-03 20:58:58.294930-04:00 0.0|Publishing:maestro/pir 2021-08-03 20:58:58.294930-04:00 0.0
Data:2 Audio 2021-08-03 20:58:58.294930-04:00 0.112|Publishing:maestro/audio 0.112
Data:2 Color Temp (K) 2021-08-03 20:58:58.294930-04:00 5836.0|Publishing:maestro/color temp 5836.0
Data:2 Lumosity 2021-08-03 20:58:58.294930-04:00 118.0|Publishing:maestro/lumosity 118.0
Data:2 R 2021-08-03 20:58:58.294930-04:00 138.0|Publishing:maestro/r 138.0
Data:2 G 2021-08-03 20:58:58.294930-04:00 178.0|Publishing:maestro/g 178.0
Data:2 B 2021-08-03 20:58:58.294930-04:00 161.0|Publishing:maestro/b 161.0
Data:2 C 2021-08-03 20:58:58.294930-04:00 500.0|Publishing:maestro/c 500.0
Data:2 Temperature 2021-08-03 20:58:58.294930-04:00 26.68|Publishing:maestro/temp 26.68
Data:2 Pressure 2021-08-03 20:58:58.294930-04:00 1015.453|Publishing:maestro/press 1015.453
Data:2 Approx. Altitude 2021-08-03 20:58:58.294930-04:00 -18.327|Publishing:maestro/alt -18.327
```

Publishing sensor data messages to webpage

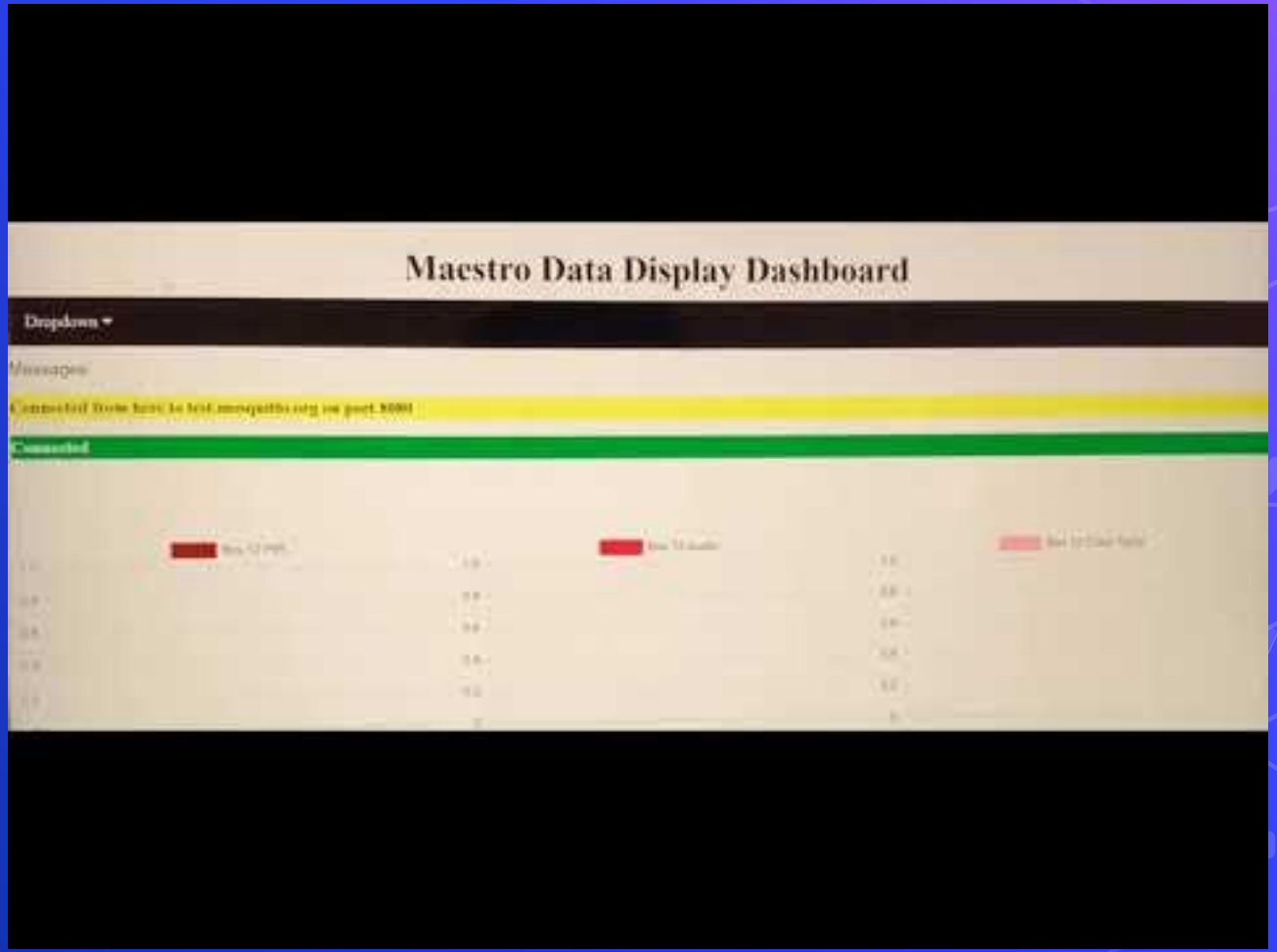
Live Demo Webpage

TECHNICAL DETAILS

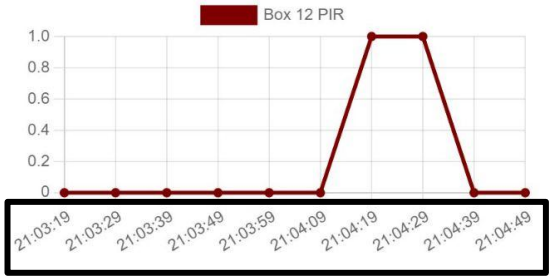
- HTML and Javascript
- MQTT: open-source messaging tool which allows for transfer of data across different platforms
- 18 values stored in respective arrays and points are plotted on corresponding graphs

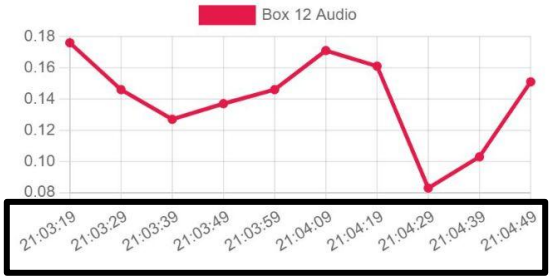
DESIGN

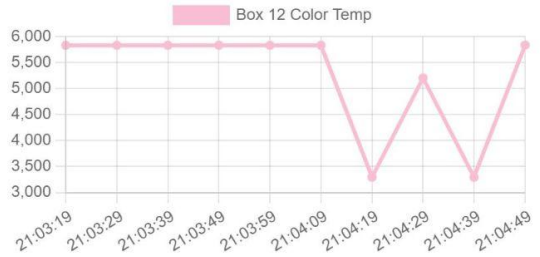
- Chart.js: to generate plots and customize design aesthetics
- 18 line plots being updated every 10 seconds
- Drop down menu to select box name

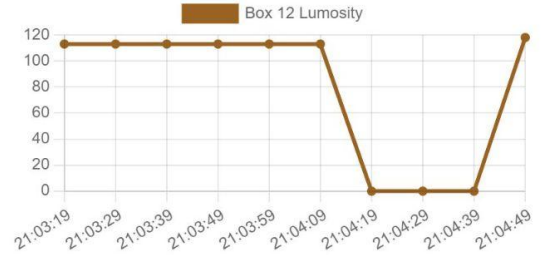

Maestro Data Display Dashboard
Dropdown
Messages
Connected

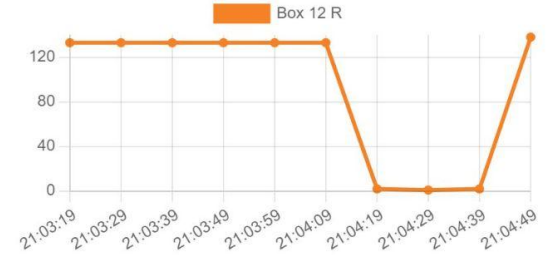
Sample Data from Maestro Sensors

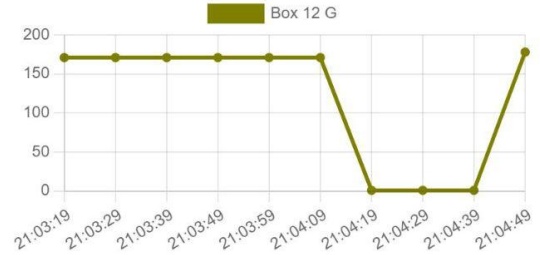


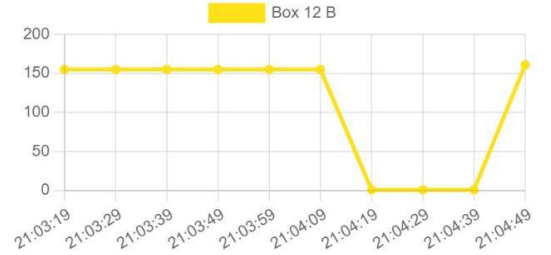


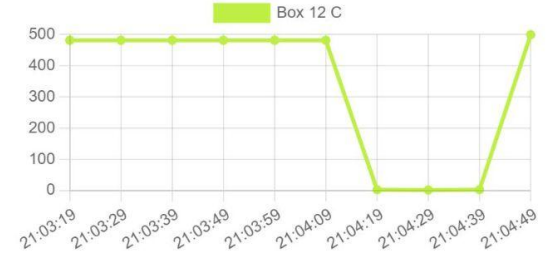


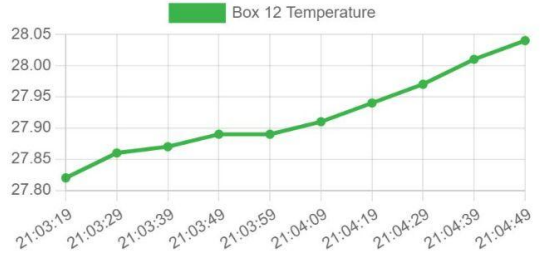




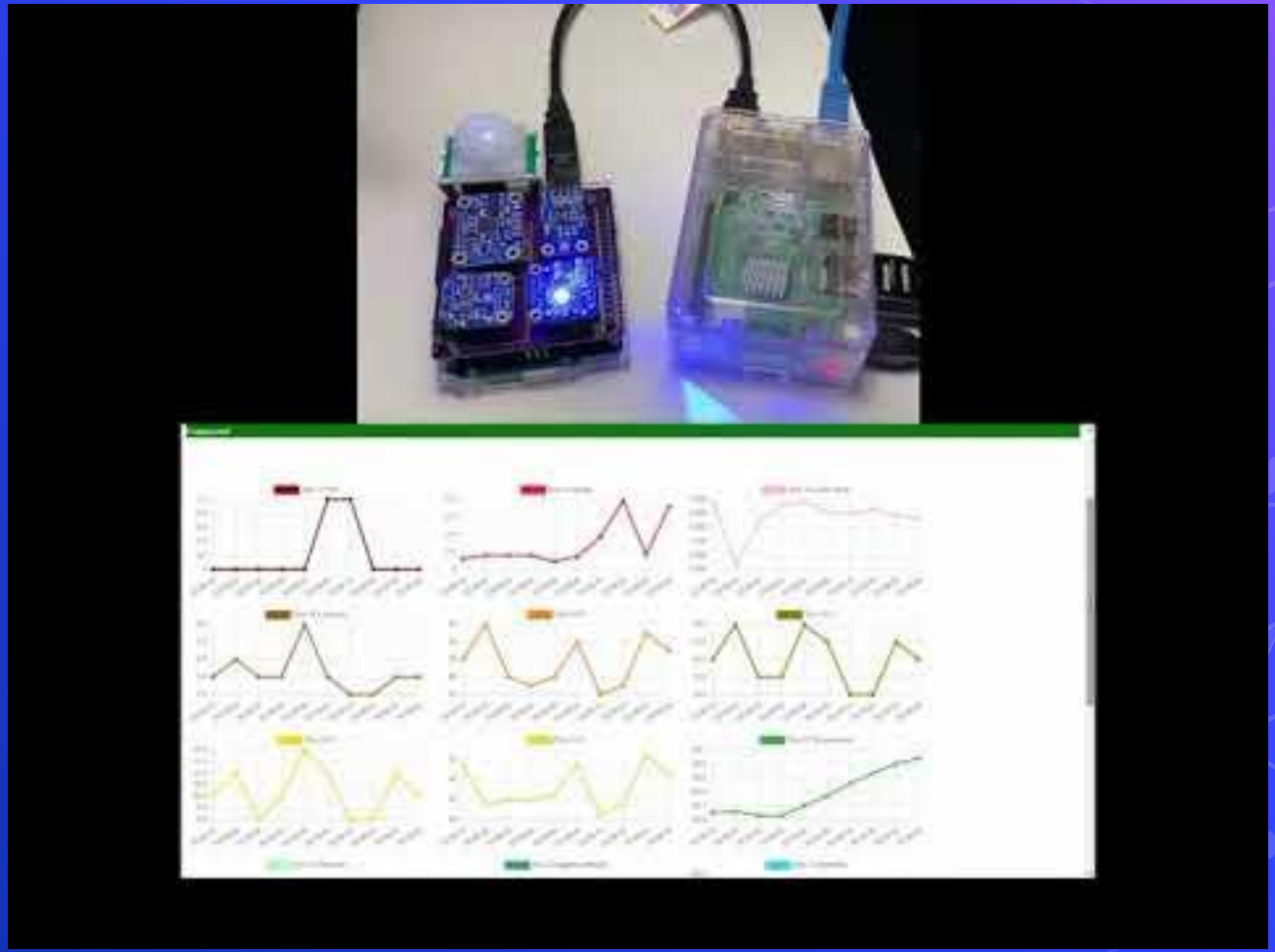








Sample Data from Maestro Sensors



Future Work

- Add live video feed on webpage
- Establish user-driven experimental framework
- Train ML model to eliminate need for camera
- Deploy maestro

Thank you for listening

Any questions?

Want to learn more about our project?

Website:

https://npai60.wixsite.com/maestro

References

Chowdhury, T., Aldeer, M., Laghate, S., Yu, J., Ding, Q., Florentine, J., & Ortiz, J. (2021). *Poster: Maestro -- An Ambient Sensing Platform With Active Learning To Enable Smart Applications*. International Conference on Embedded Wireless Systems and Networks (EWSN), Delft, The Netherlands. ISBN: 978-0-9949886-5-2