Improving Interactions with Virtual Reality Objects in the AWS Cloud using IoT Wearable Devices

Anthony Mancini (Project Lead, VR, Data Analysis)
Gregory Retter (Wearable Design, Data Collection)
Brian Wagner (Documentation)
Nawal Al-Harbi (Support)

Project Idea

- Move a similar object in the physical world and in Virtual Reality using the STMicroelectronics Sensor Tile
- Host the virtual object within the AWS cloud, adding in latency when interacting with the object
- Build a model to predict the movements
  - Use the model to understand if the virtual physics have a natural feel

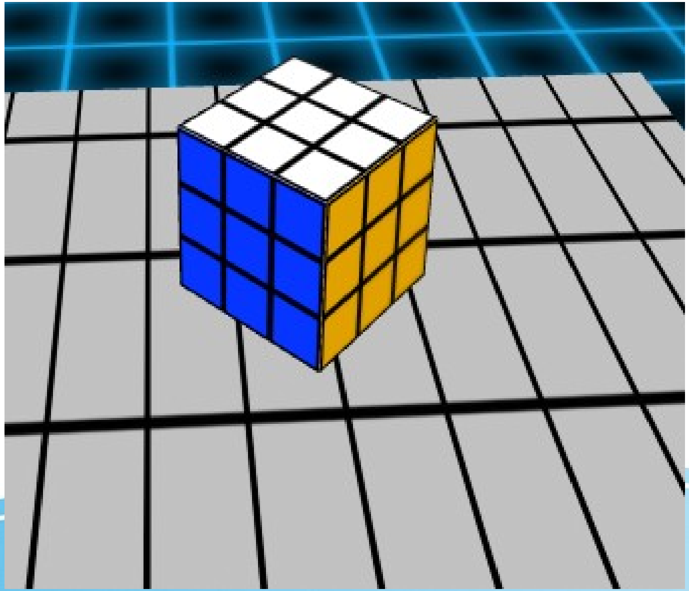
Project Time Frame

- Weeks 1-3
  - Completed tutorials and got familiar with the Sensor Tile
- Weeks 4-5
  - Created the VR scene and the VR cube
  - Connected the VR scene to the cloud
  - Connected the glove to the cloud
- Weeks 6-7
  - Ran the trials and collected the data
  - Analyzed the data and built the model

Building the Prototype

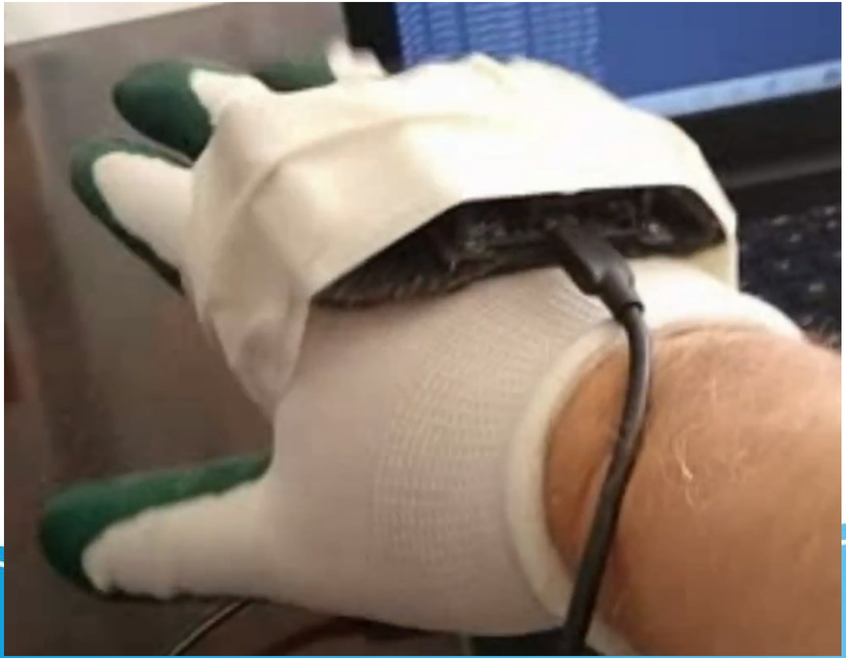
Physical Cube

Virtual Cube

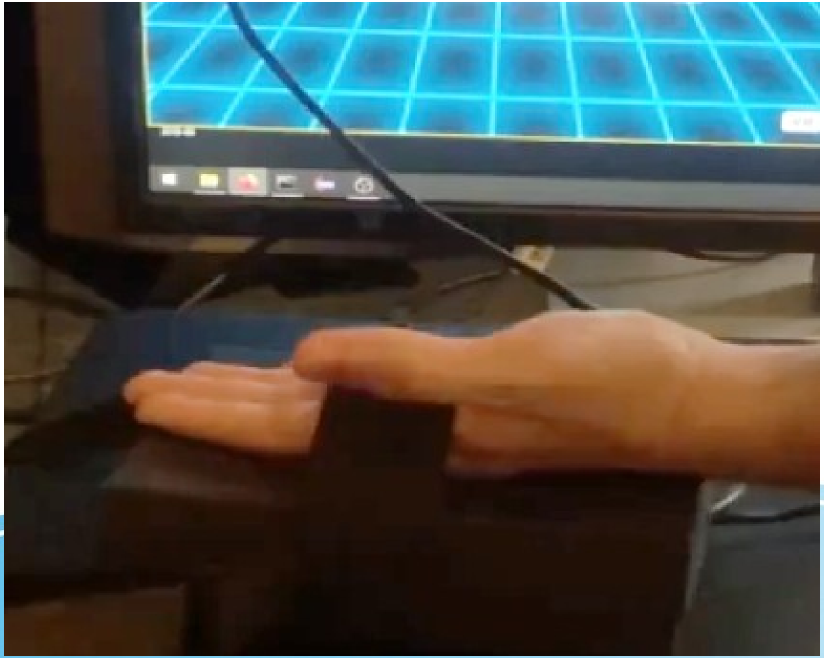


Building the Prototype

Glove for Physical Cube



Glove for Virtual Cube



Data Collection

- To collect data, we threw both cubes up in the air
    - Measures the Y-Acceleration and a Timestamp
    - Used three different height for the throws:
        - 1 foot
        - 2 feet
        - 3 feet
    - Virtual height was measured relative to the size of the cube
        - 1ft ≈ 5-6x the cube size

Demonstration

Link to video:

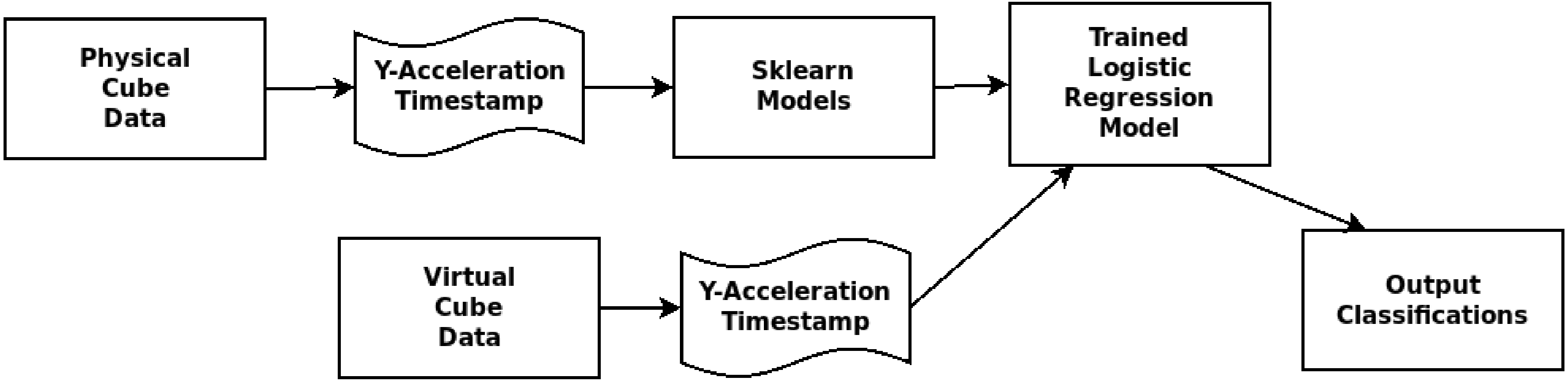
https://github.com/anthony-mancini/dgmd-s-14-project/blob/master/video/final-project-video.mp4

Machine Learning

- We used Logistic Regression for our model
  - Classification Model
  - Supervised Model (our data was labeled)
  - Tries to predict how we interacted with the virtual cube:
    - Input Y-Acceleration and output what type of throw it was (1 foot, 2 feet, or 3 feet)

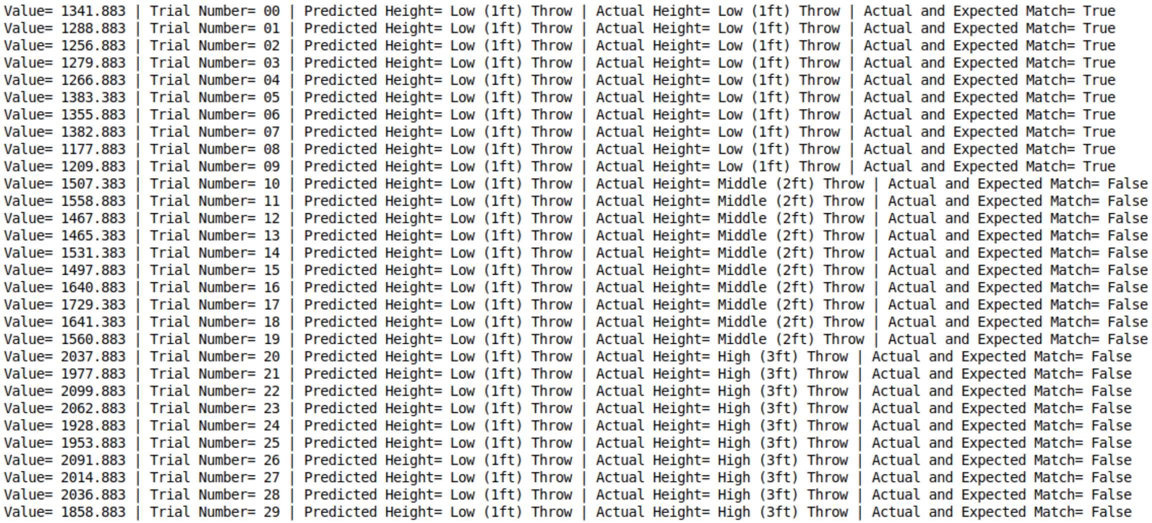
Model Flow Chart

Data Collection / Segmentation / Features / Classification



Results

- Logistic Regression can be used to help give VR/AR a more natural feel
- The physics library was too sensitive (can be improved)
- Latency wasn't an issue!
    - The network has improved enough to allow real-time interactive VR applications



```
Value= 1341.883 | Trial Number= 00 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1288.883 | Trial Number= 01 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1256.883 | Trial Number= 02 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1279.883 | Trial Number= 03 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1266.883 | Trial Number= 04 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1383.383 | Trial Number= 05 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1355.883 | Trial Number= 06 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1382.883 | Trial Number= 07 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1177.883 | Trial Number= 08 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1209.883 | Trial Number= 09 | Predicted Height= Low (1ft) Throw | Actual Height= Low (1ft) Throw | Actual and Expected Match= True
Value= 1507.383 | Trial Number= 10 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1558.883 | Trial Number= 11 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1467.883 | Trial Number= 12 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1465.383 | Trial Number= 13 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1531.383 | Trial Number= 14 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1497.883 | Trial Number= 15 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1640.883 | Trial Number= 16 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1729.383 | Trial Number= 17 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1641.383 | Trial Number= 18 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 1560.883 | Trial Number= 19 | Predicted Height= Low (1ft) Throw | Actual Height= Middle (2ft) Throw | Actual and Expected Match= False
Value= 2037.883 | Trial Number= 20 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
Value= 1977.883 | Trial Number= 21 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
Value= 2099.883 | Trial Number= 22 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
Value= 2062.883 | Trial Number= 23 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
Value= 1928.883 | Trial Number= 24 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
Value= 1953.883 | Trial Number= 25 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
Value= 2091.883 | Trial Number= 26 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
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Value= 2036.883 | Trial Number= 28 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
Value= 1858.883 | Trial Number= 29 | Predicted Height= Low (1ft) Throw | Actual Height= High (3ft) Throw | Actual and Expected Match= False
```
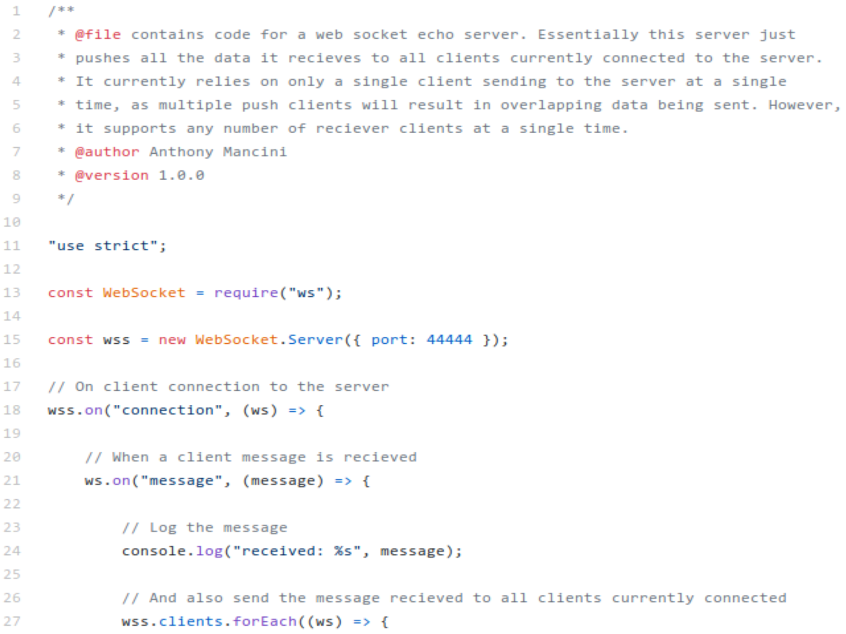

Future Improvements

- Inform VR/AR physics library creators of our results
  - Show them how they can use the Sensor Tile with their libraries
  - Make future VR applications feel more natural
- More interactions
  - Move two hands at the same time
  - Include X- and Z-Acceleration

Code - JavaScript

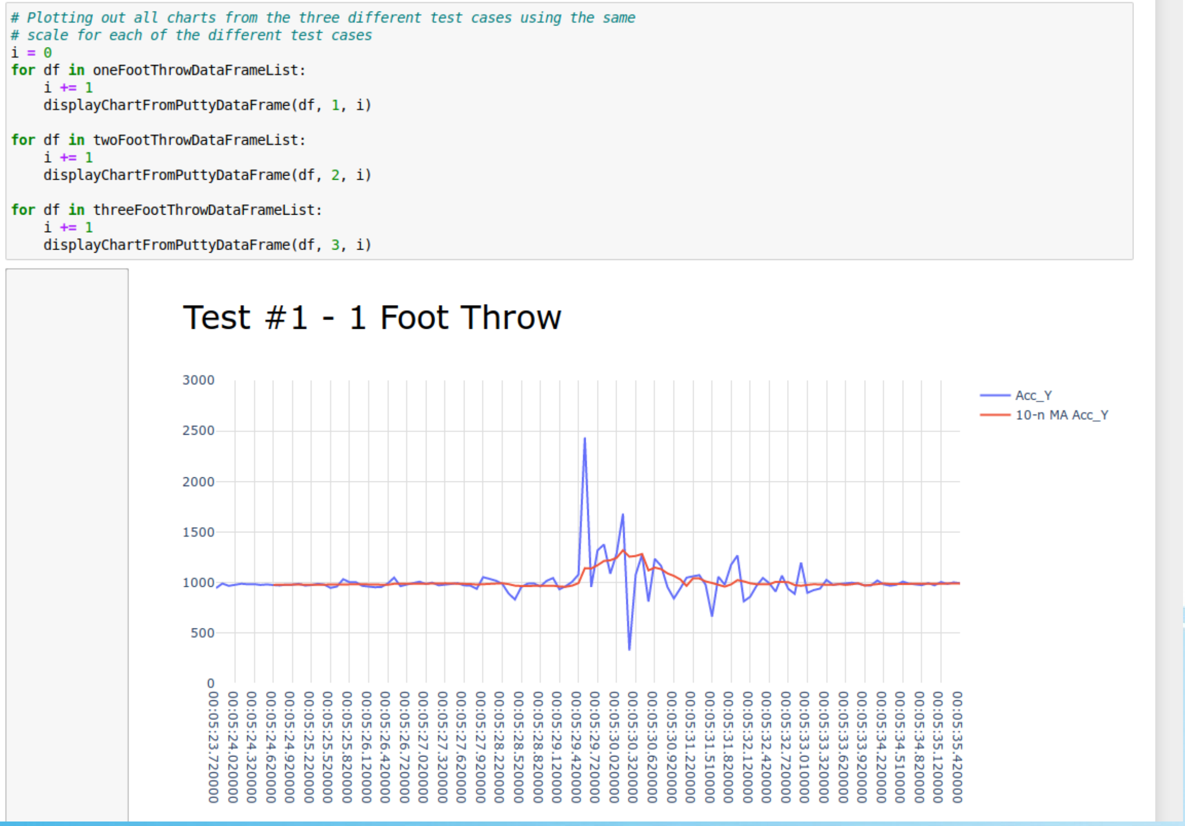
- WebSocket server and client code (ws library)
- Connected the glove to the server in the cloud (serialport library)



```javascript
/**
 * @file contains code for a web socket echo server. Essentially this server just
 * pushes all the data it recieves to all clients currently connected to the server.
 * It currently relies on only a single client sending to the server at a single
 * time, as multiple push clients will result in overlapping data being sent. However,
 * it supports any number of reciever clients at a single time.
 * @author Anthony Mancini
 * @version 1.0.0
 */

"use strict";

const WebSocket = require("ws");

const wss = new WebSocket.Server({ port: 44444 });

// On client connection to the server
wss.on("connection", (ws) => {

    // When a client message is recieved
    ws.on("message", (message) => {

        // Log the message
        console.log("received: %s", message);

        // And also send the message recieved to all clients currently connected
        wss.clients.forEach((ws) => {
```

Code - Python

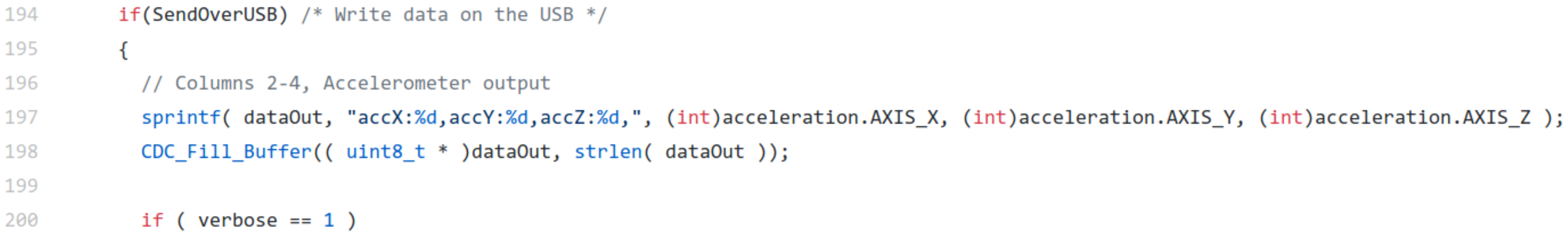
- Used for Data Analysis and Logistic Regression Model (pandas and sklearn libraries)
- Jupyter Notebook for the analysis



```
# Plotting out all charts from the three different test cases using the same
# scale for each of the different test cases
i = 0
for df in oneFootThrowDataFrameList:
    i += 1
    displayChartFromPuttyDataFrame(df, 1, i)

for df in twoFootThrowDataFrameList:
    i += 1
    displayChartFromPuttyDataFrame(df, 2, i)

for df in threeFootThrowDataFrameList:
    i += 1
    displayChartFromPuttyDataFrame(df, 3, i)
```

Code - C

- Modification of the STM Sensor Tile DataLog Project to export in keyed CSV format



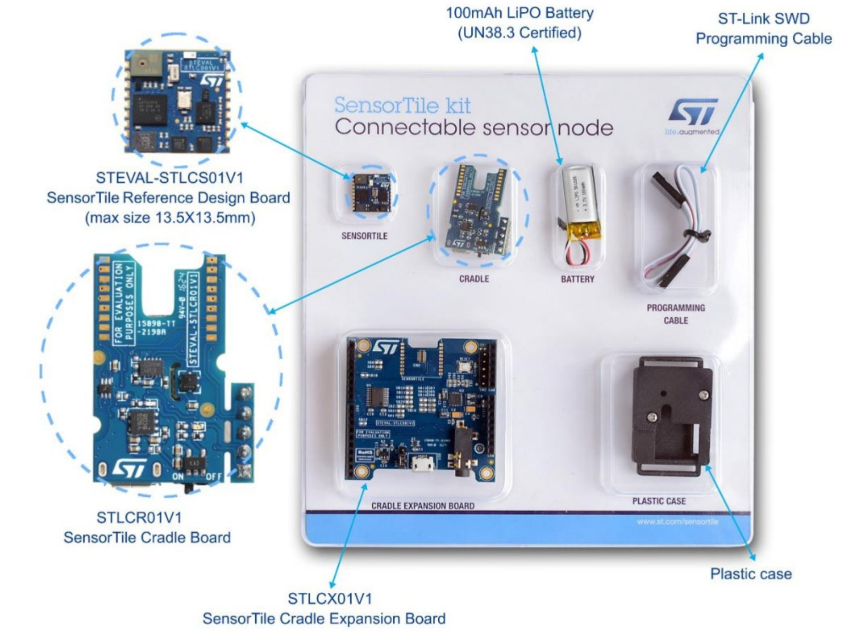
```
    if(SendOverUSB) /* Write data on the USB */
    {
      // Columns 2-4, Accelerometer output
      sprintf( dataOut, "accX:%d,accY:%d,accZ:%d,", (int)acceleration.AXIS_X, (int)acceleration.AXIS_Y, (int)acceleration.AXIS_Z );
      CDC_Fill_Buffer(( uint8_t * )dataOut, strlen( dataOut ));

      if ( verbose == 1 )
```

Software

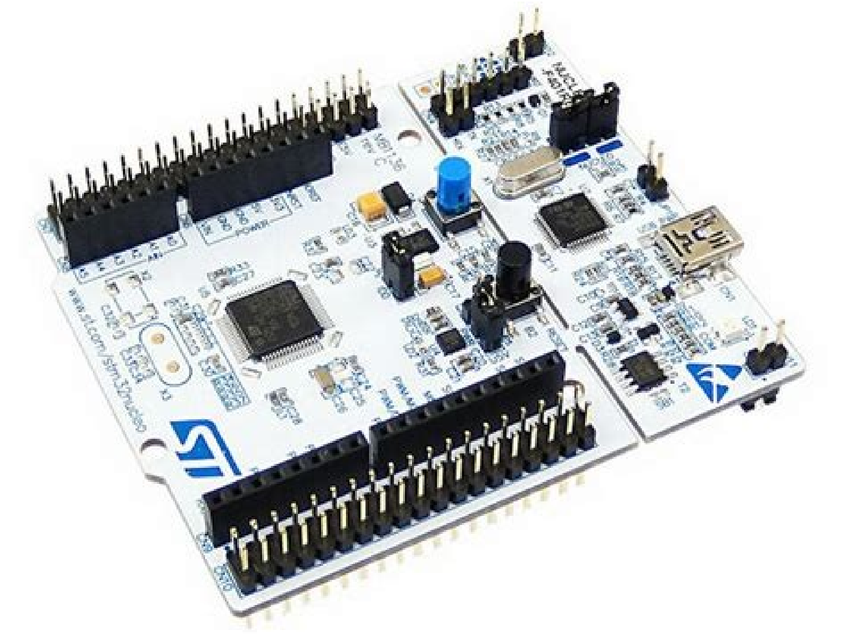
- IDEs and Text Editors:
    - VS Code
- Software libraries and languages
    - Python
        - Data Science packages (such as Pandas, Sklearn, etc.)
    - JavaScript
        - A-frame
        - Web sockets
    - C (for the Sensor Tile)

Hardware

ST Sensor Tile



ST Nucelo Board



Jupyter Notebook

Link: https://github.com/anthony-mancini/dgmd-s-14-project/blob/master/data-analysis/data-analysis.html

Any Questions?