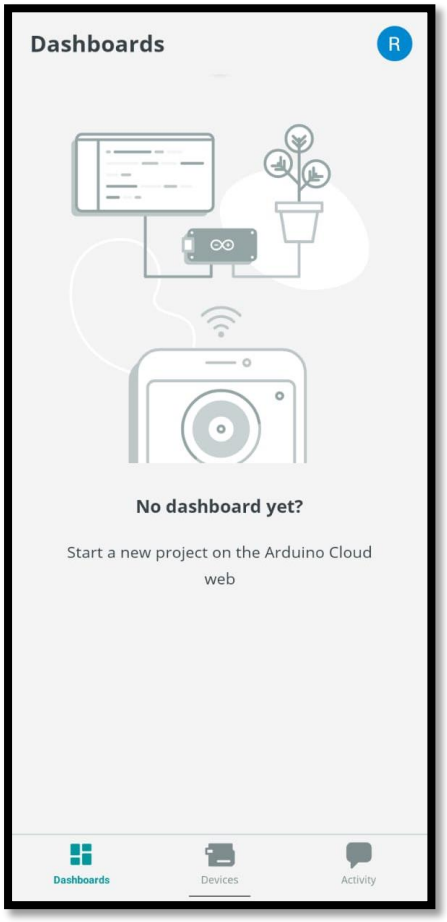
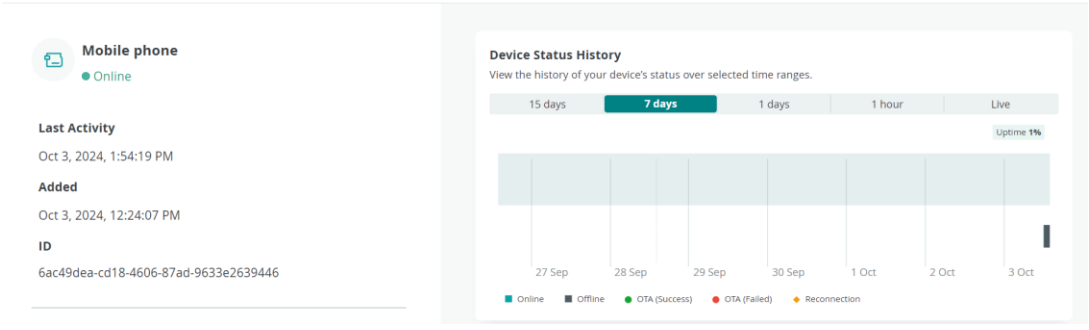
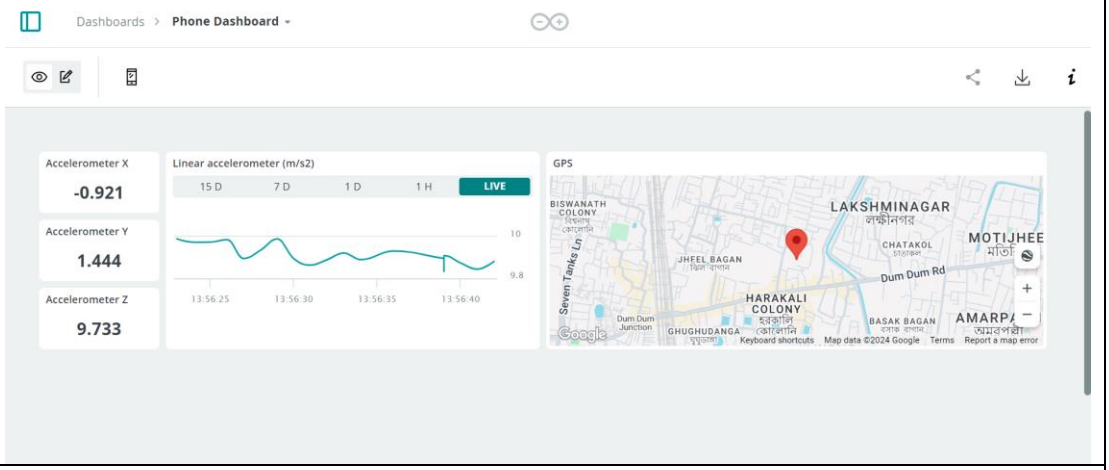
Using smartphone to capture sensor data

Step	Action
1	**Install App**: 
2	**Add device**: Added 
3	**Keep your smartphone screen ON for a while**:

	Question: Take a screenshot of your Ardiuno Cloud Dashboard where smartphone data is streaming and paste it here. Answer: 
4	**Plot accelerometer data**: Question: Open Jupyter Notebook by using command line, go to the data folder and write command ($ jupyter lab). Using Pandas, read CSV file and fetch the data column for accelerometer_x and plot it using Python plotting library (matplotlib or any other convenient for you). Repeat the plotting process for accelerometer y and z to have 3 separate graphs. Now create a fourth graph with all 3 variables x, y and z. Screenshot the 4 graphs and paste here. Answer: 

5	Question: Analyse accelerometer variables to find any repeating pattern. Remember that you were repeatedly moving your phone in a single pattern which should be manifested in the graphs. Justify your answer. Answer: The four visuals show the accelerometer data of the X, Y and Z axis that details the motion over time. The spaces of the two axes have different shapes, with clear peaks representing an abrupt movement, and then flat zones. In the combined XYZ graph, multi peaks on all three axes indicate that the phone was moving in harmony, and likely to have been shaken or tilted. This confirms what is! observed on the Z-axis is more pronounced than on the X and Y axes and indicates predominantly vertical motion The X and Y axes are less active, and yet the variations are significant enough to identify multidirectional movement. These consistencies in the motions exhibited show that there is a repeated and syncopated action of the phone.

Activity 8.2: Receive smartphone sensor data from Python script

Code-

```
import pandas as pd
import plotly.graph_objs as go
from plotly.subplots import make_subplots
import plotly.io as pio

# Use browser to render the plot if notebook rendering is not working
pio.renderers.default = 'browser'

# Load CSV files
accel_x = pd.read_csv('Thing-Accelerometer_X.csv')
accel_y = pd.read_csv('Thing-Accelerometer_Y.csv')
accel_z = pd.read_csv('Thing-Accelerometer_Z.csv')

# Define a plot with 4 subplots (one for each visual)
fig = make_subplots(rows=2, cols=2, subplot_titles=("X-Axis Acceleration", "Y-Axis
Acceleration",
                                    "Z-Axis Acceleration", "Combined XYZ Acceleration"))

# Plotting Accelerometer X-Axis Data
fig.add_trace(go.Scatter(x=accel_x['time'], y=accel_x['value'], mode='lines', name='X-
Axis'), row=1, col=1)

# Plotting Accelerometer Y-Axis Data
fig.add_trace(go.Scatter(x=accel_y['time'], y=accel_y['value'], mode='lines', name='Y-
Axis'), row=1, col=2)

# Plotting Accelerometer Z-Axis Data
fig.add_trace(go.Scatter(x=accel_z['time'], y=accel_z['value'], mode='lines', name='Z-
Axis'), row=2, col=1)

# Combined Plot of X, Y, and Z Axes
fig.add_trace(go.Scatter(x=accel_x['time'], y=accel_x['value'], mode='lines', name='X-
Axis'), row=2, col=2)
fig.add_trace(go.Scatter(x=accel_y['time'], y=accel_y['value'], mode='lines', name='Y-
Axis'), row=2, col=2)
fig.add_trace(go.Scatter(x=accel_z['time'], y=accel_z['value'], mode='lines', name='Z-
Axis'), row=2, col=2)
```

```
# Update layout for better visualization
fig.update_layout(title='Accelerometer Data Visuals',
                  xaxis_title='Time', yaxis_title='Acceleration',
                  showlegend=True, height=800, width=1200)

# Show the plot
fig.show()
```

Output-

Analysis of Ontrack task.”

Summary of Accelerometer Activity Separation

Introduction

Magnetic accelerometers detect the rates of change in velocity and hence enable the use in identifying motion patterns in more than one plane. In this activity, acceleration data along X, Y, and Z axes were sampled using an accelerometer and the differentiation of activities was based on the motion in these three planes. This analysis involved creating and interpreting visual plots that would help identify pattern related to certain motion for instance shaking or tilting the phone.

Method

This analysis was done by getting time series data of the X, Y, and Z axes of the accelerometers. Each axis corresponds to a directional component:

- X-axis: Stands for the lateral direction (left and right).
- Y-axis: Stands for the up-down movment.
- Z-axis: Stands for movement from the future to the past.

The following steps outline the method used to separate activities based on accelerometer readings:

1. Data Collection: The motion information was collected using the smartphone's accelerometer as a sensor of continuous time intervals. The number of data points about the X, Y and Z axes was collected – any important movements of the phone were recorded.

2. Visualization: After importing the data and before cleaning it, the data was plotted with Plotly and pandas to visualize the movement in the three axes. For each position, two line graphs for each axis were presented to view the movements of each axis separately, and the superimposed graph showed the simultaneous movement of all axes.

3. Pattern Detection: Such data analysis was applied to the graphs in order to define surge and stagnant times. These spikes are representative of significant motion, such as shake, and tilt while the flat or relatively flat phases refer to a stationary or slow motion state.

Results

The analysis of the accelerometer data revealed several key insights:

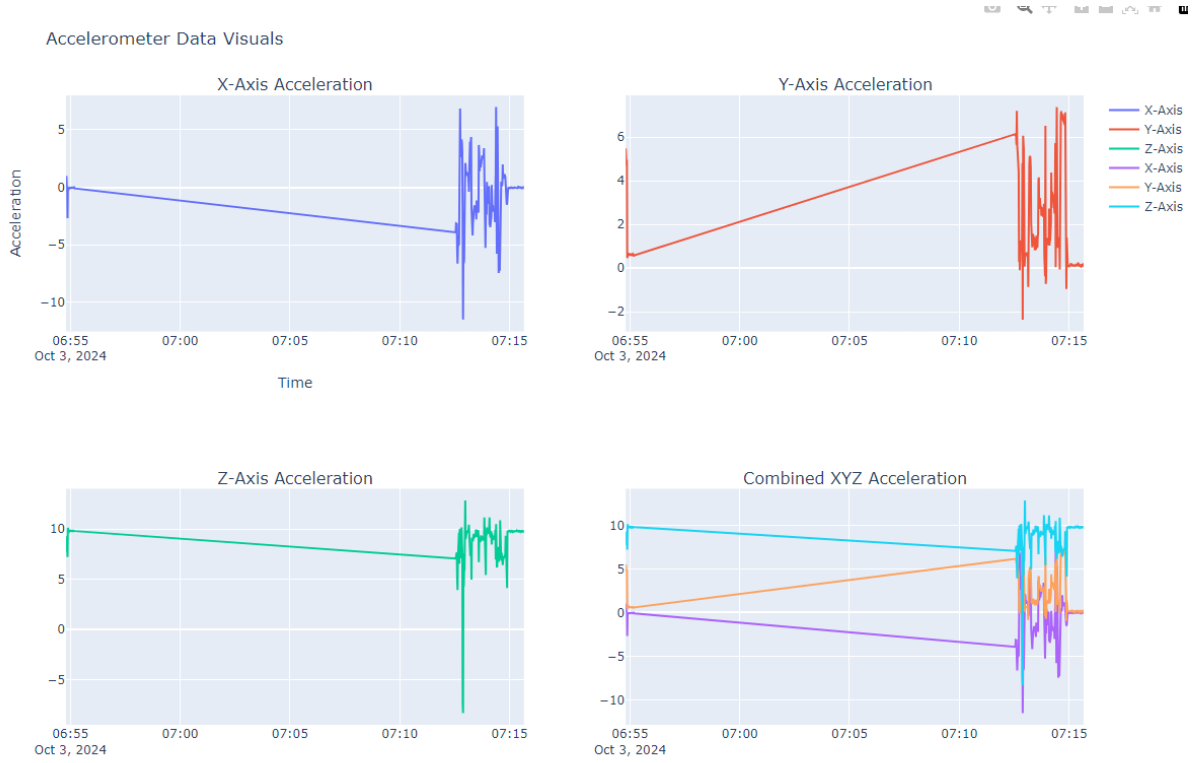


Figure 1: Key Insight

1. Repeated Motion Indication:

   In each graph (X, Y, Z), there were noticeable spikes that indicated sudden motion. After the spikes, the signals settled into relatively steady values, meaning that the phone was at rest or moving slowly. This pattern of sharp spikes followed by calm periods suggests repeated sudden movements.

2. Time Correlation Across Axes:

   The peaks in the X, Y, and Z graphs occurred at approximately the same time, indicating a coordinated movement across all directions. This synchronization suggests that the phone was moved in a way that affected all axes simultaneously, such as shaking or tilting.

3. Amplitude and Axes Involvement:

   The Z-axis showed the largest amplitude, indicating that the primary movement was along the Z-axis (up and down). The X-axis and Y-axis exhibited lower amplitudes, suggesting that while there was movement in these directions, it was less pronounced compared to the Z-axis.

4. Repeating Pattern Justification:

   The consistent peaks followed by calm periods across all three axes suggest a repeated motion pattern. Since this pattern appeared simultaneously in all three axes,

it is likely that the phone was moved in a coordinated manner, such as shaking it in a consistent direction or force. The analysis supports the observation of repeated, synchronized motion.

Discussion

The decomposition of the triaxial accelerations provided a clean differentiation between different activities based on characteristic motion signals. This provided a larger spectrum for the understanding of how the phone is being moved since motion could detected in all flight directions.

- Coordinated Movement: The fact that the peaks are recorded at the same time for each ephone was shifted in a cyclic behaviour and most probably the shifting was accompanied by the same force each time.

By comparing accelerometer data, this analysis demonstrates the importance of data in identifying and categorising various movements. As the motions were observed across the multiple axes, it was possible to detect synchronization of the movements and define the dominant direction of the motion. Furthermore, typical MPAs such as repeated motion pattern were made visible, pointing towards a structured or repeated activity.

Conclusion

The accelerometer data effectively captured and distinguished different motion patterns. The method of visualizing data from multiple axes allowed for a detailed analysis of how the phone was moved. The results showed clear evidence of repeated, coordinated motion, primarily in the vertical direction. This analysis demonstrates the power of accelerometer data in separating and analyzing different activities based on movement patterns.

Bibliography

Gao, Z., Liu, W., McDonough, D.J., Zeng, N. and Lee, J.E., 2021. The dilemma of analyzing physical activity and sedentary behavior with wrist accelerometer data: challenges and opportunities. *Journal of Clinical Medicine*, *10*(24), p.5951.

Maczák, B., Vadai, G., Dér, A., Szendi, I. and Gingl, Z., 2021. Detailed analysis and comparison of different activity metrics. *Plos one*, *16*(12), p.e0261718.