Mission Space Lab Phase 4 report

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Chosen theme: Life in Space

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1. Introduction

The ISS is the largest man-made object to orbit the Earth. It maintains an orbit at an average altitude of 400 kilometres. Our experiment aims to monitor the station's movement and rotation, providing attitude control warnings to the crew. With the collected data, we expect to identify events that might occur such as the docking and undocking of spacecraft, the correction of altitude or minor situations that result from the intervention of astronauts on the Astro Pi equipment or its surroundings.

2. Method

Our code collected the data from the Inertial Measurement Unit (gyroscope and accelerometer sensors inside the Astro Pi) that records the orientation and the X, Y and Z axes accelerometer readings, every 4 seconds. We analysed then to identify events that might have occurred. We also used the PIR motion sensor to detect if a crew member was near the Astro Pi and be responsible for the variation in accelerometer values. The temperature and humidity were also analysed to detect variations in the cabin, which, together with the PIR sensor, could prove the presence of an astronaut in the module.

3. Experiment results

According to the log file, our code ran on April 16 from 14:58:11 to 17:53:15 (UTC) and the PIR sensor was activated 138 times and there were 31 warnings caused by the variation in the accelerometer values. Since it was a Saturday, there are no details in the ISS Daily Summary Report about the presence of astronauts on the Columbus module.

The measurements from the sense hat were written to a CSV file every 4 seconds, making a total of 2469 entries. The data acquired by the sensors of the Inertial Measurement Unit was used to create the graph represented in Figure 1.

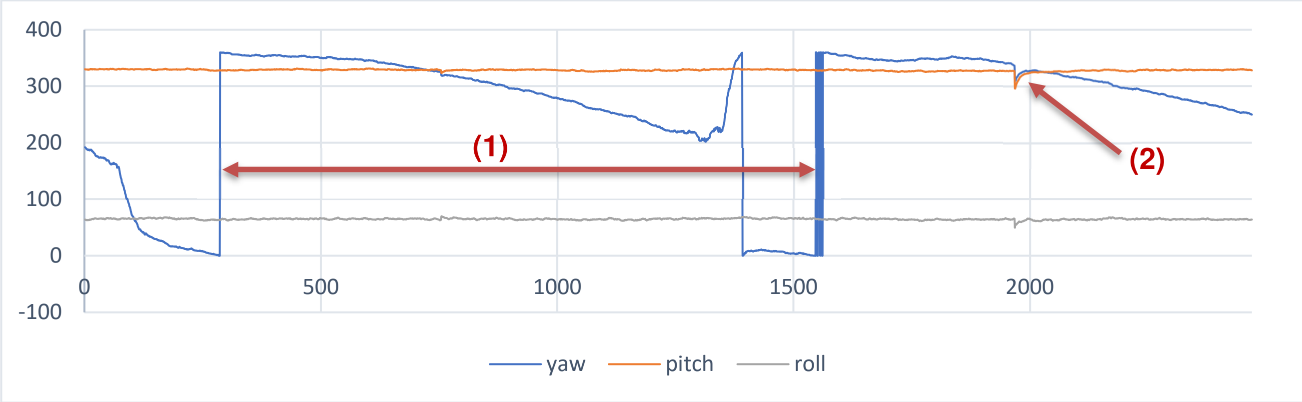

Figure 1: Orientation versus entry counter

From the yaw data, we can determine the time it takes the ISS to complete one orbit (there is a cyclic pattern caused by the rotation movement around an axis so that the station is always facing Earth in the same way), which gives us a period of 91 minutes (1).
The graph in Figure 1 also shows a singular event (2) detected at 17:17:36 (UTC) that causes a significant change in the sensor's values (Figure 2).

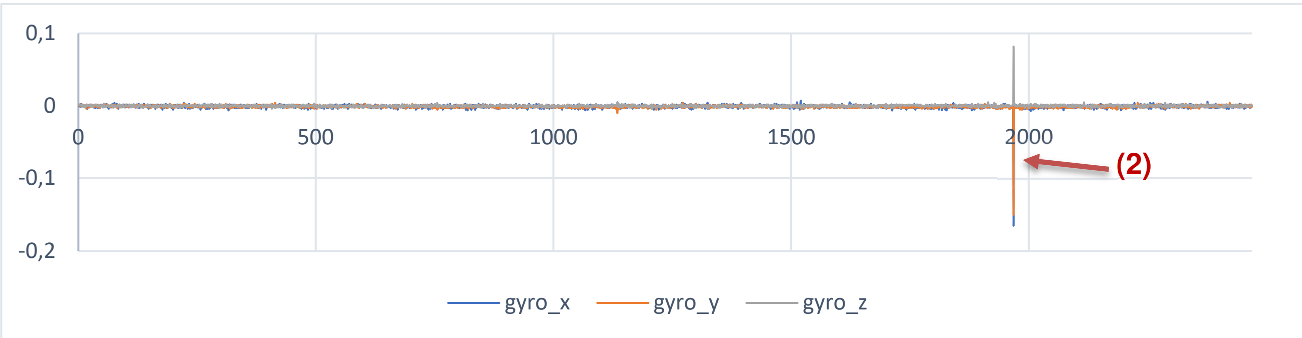

Figure 2: gyro sensors versus entry counter

The Figure 3 shows X, Y and Z axes accelerometer readings during the experiment with the events recorded from the PIR and IMU sensors.

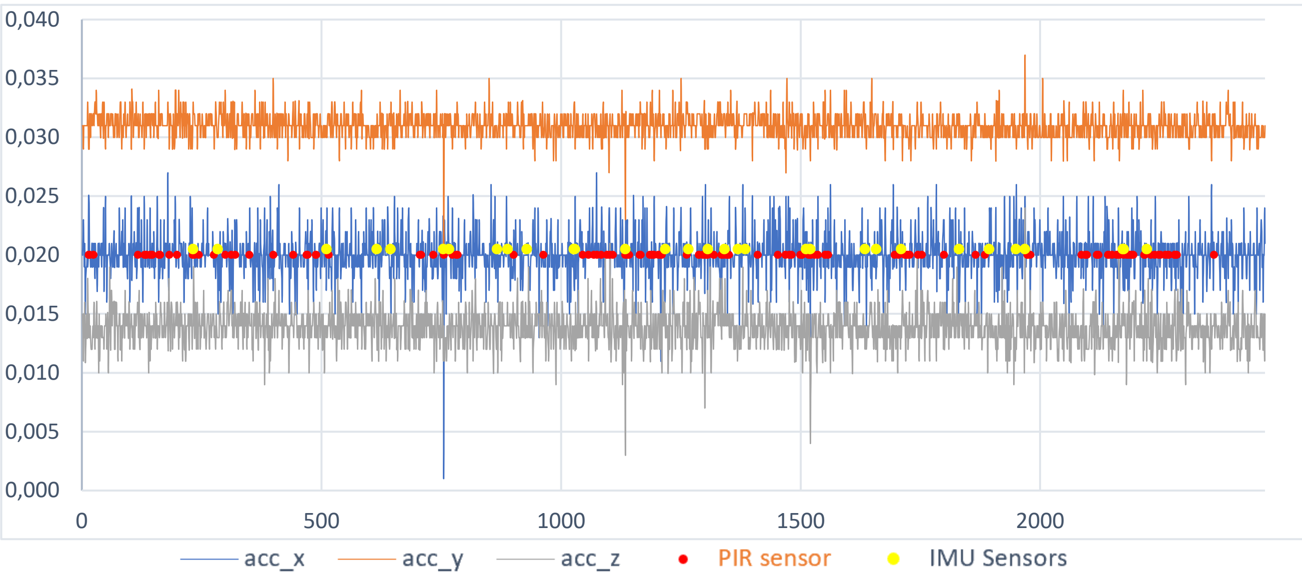

Figure 3: Acceleration, PIR, IMU versus entry counter

The log file recorded 138 events from the PIR sensor and 31 from the IMU sensors, and some of those events could be correlated with variations of X, Y and Z axes.

To determine if the presence of astronauts can affect the temperature and humidity in the module, we plot the graph in figure 4.

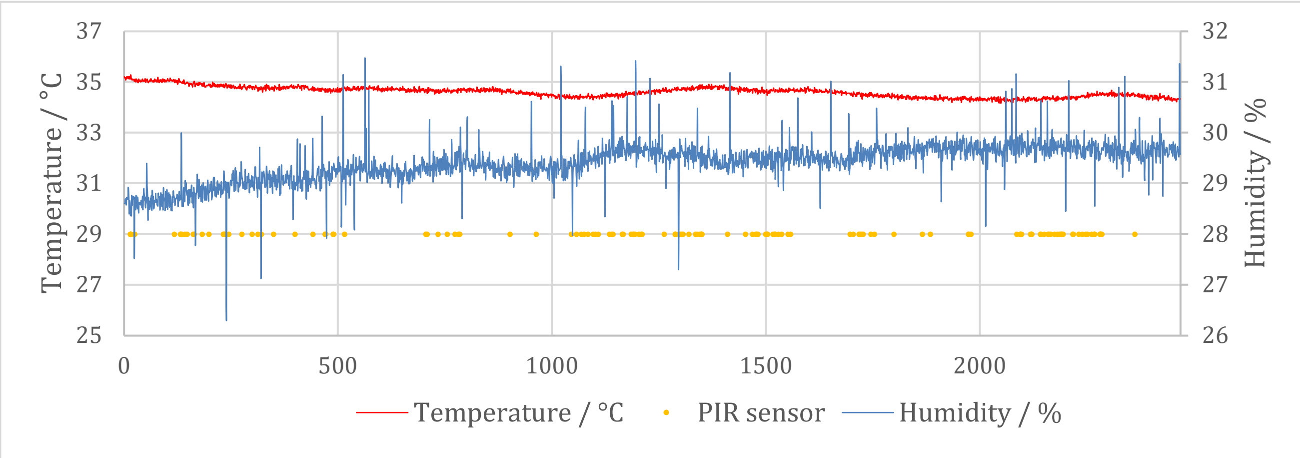

Figure 4: Temperature, Humidity and PIR versus entry counter

The percentage of humidity tends to increase when the PIR sensor registers greater activity and to decrease when it does not register activity. This correlation is not noticeable with temperature. Thus, we can conclude that the presence of astronauts can be proven by the variation of cabin humidity.

We used Google Earth and Google Maps to show the trajectory of the ISS during our experiment and display the data acquired from each entry (Figures 5 and 6).
The all data can be viewed at:
https://www.google.com/maps/d/edit?mid=1dngDYfL_6pGwH621Ou35v13dEF_nBCg&usp=sharing

Figure 5: ISS Trajectory on Google Earth

Figure 6: ISS Trajectory on Google Maps

The ISS travels from west to east at an orbital inclination of 51.6 degrees (Figure 5). As the station completes one orbit, the Earth rotates eastward by 22.5° (1.5 hr/ 4 hr)×360°. Thus, the trajectory shifts westward (relative to the Earth's surface) by that amount of longitude each turn, as we can see in Figure 6.

We also plotted the ISS altitude over time and found a pattern we didn't expect (Fig. 7).

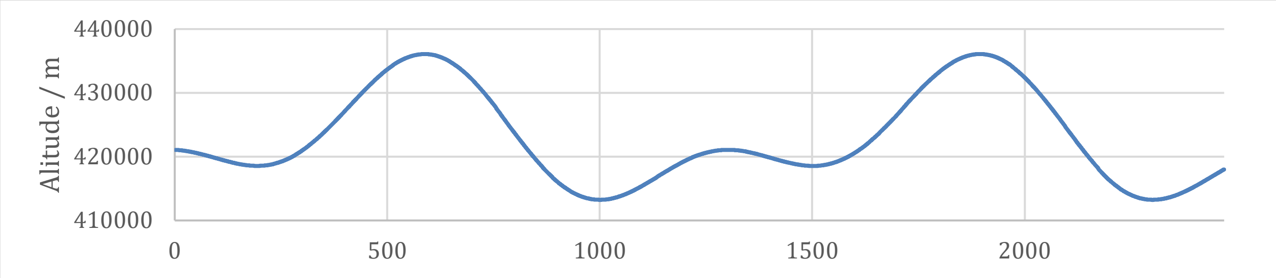

Figure 7: Altitude versus entry counter

To understand the cause of the altitude variation in this way, we overlay altitude data with latitude (Figure 8).

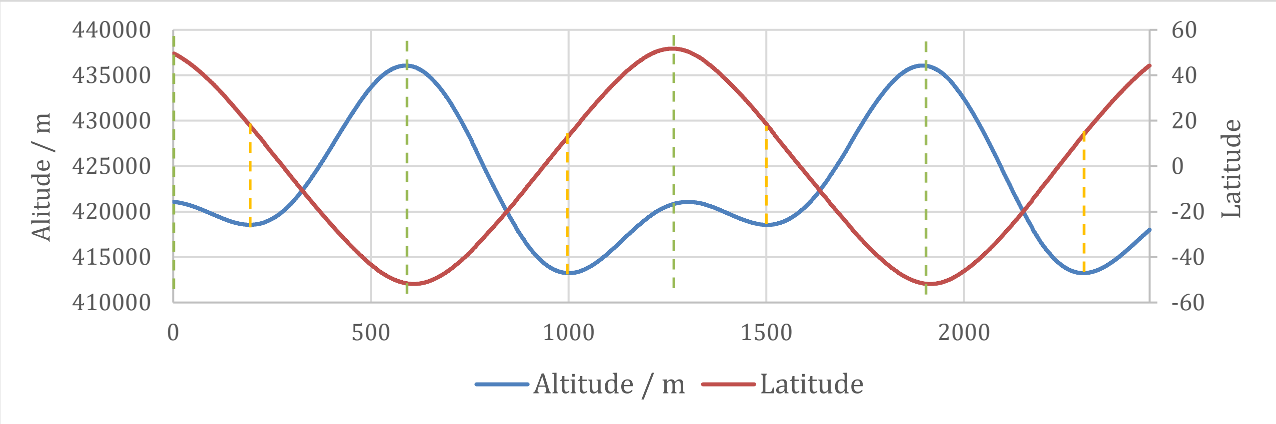

Figure 8: Altitude and latitude versus entry counter

We conclude that the peaks correspond to maximum North/South latitudes (dashed green lines) and troughs to equatorial latitudes (dashed orange lines). Because the ISS's orbit is not perfectly circular and the Earth is not spherical, the altitude varies by a few kilometres. Therefore, two consecutive peaks have different altitude values due to the eccentricity of the orbit. The same occurs with two consecutive troughs.

4. Learnings

We learned a lot about python coding and build our own Astro Pi. We also learned more about Excel for analysing data and studying the trajectories of space orbit.

5. Conclusion

Our code was able to monitor the ISS movement and detect sudden changes, providing alerts. The PIR sensor detected the presence of astronauts in the module and we were able to correlate these events with the increase in humidity.

We are very pleased with the results achieved and with the knowledge we have acquired throughout the project.

Thank you.

Project data and code can be found at:

https://github.com/Robotica2022/Astro-Pi2022