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Chosen theme: Life in Space
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Introduction

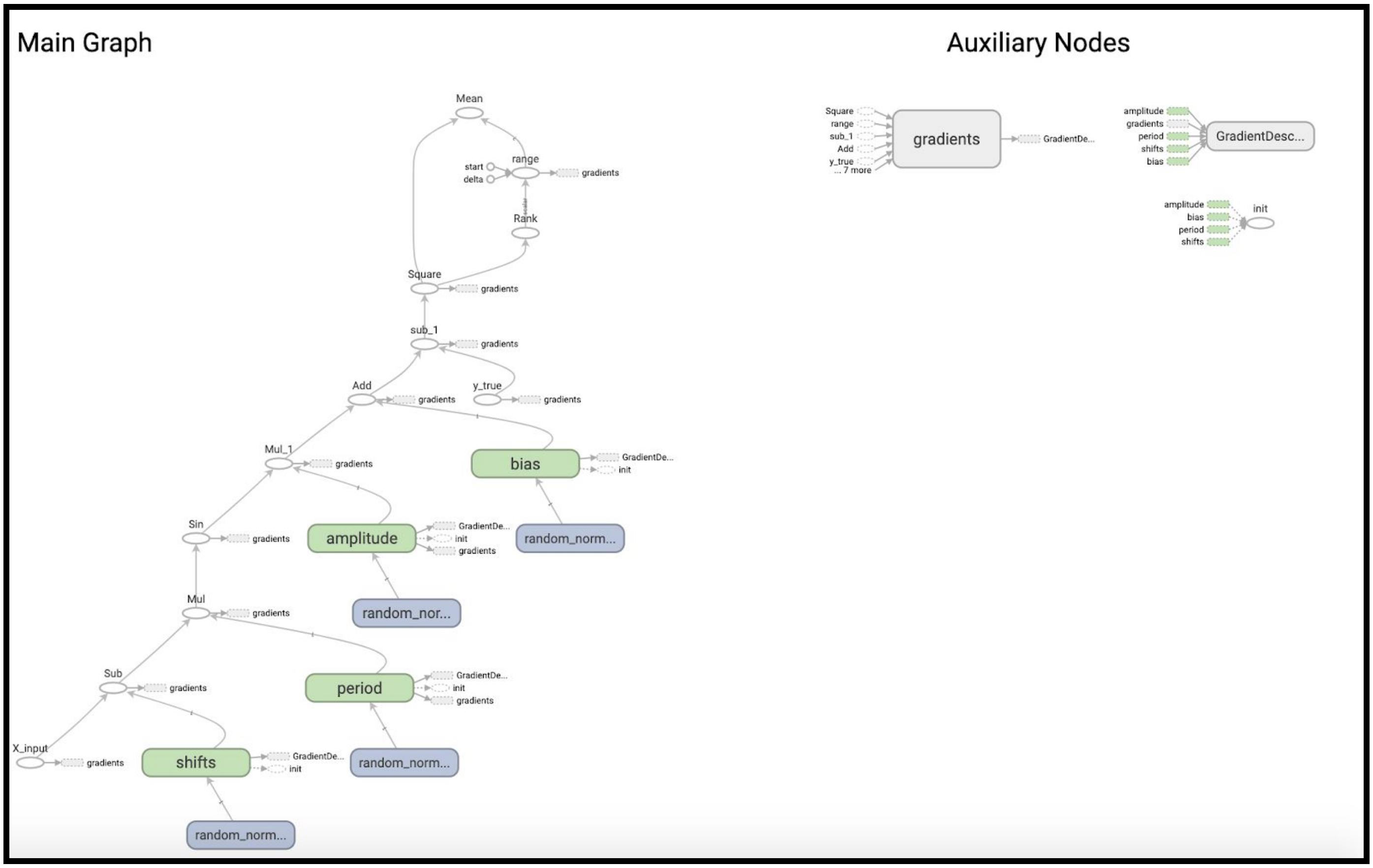
The purpose of this study was to investigate and analyze the positional data and the time intervals between re-boosts of the International Space Station (ISS) to develop a system to accurately calculate the potential vectors of the ISS's position relative to Earth. Additionally, this project aimed to provide a basis of knowledge required to conduct a more extensive investigation to trace the trajectory of the ISS under two different conditions (trajectory with no re-boosts and trajectory with re-boosts), which aims to assist astronauts to decide whether re-boosts are necessary under a given condition. Our group was interested in investigating the relationship between time (our independent variable) and the trajectory/position of the ISS (our dependent variables). We hypothesized that we would be able to determine the specific times of re-boosts using only positioning data and accelerometers and that the historical data regarding the position of the ISS would be essential to predict the space station's position.

Method

The code our group devised was developed to predict the position of the ISS, and to calculate the time of re-boosts from the data sets collected over two-second intervals. We used the positional data to investigate how the position of the ISS changed over time, and how that position compared to its acceleration. While other data points were collected through the use of SenseHat’s humidity, temperature, and barometric pressure sensors, among others, we used the IMU sensor data, which measures the orientation (pitch, roll, yaw) via gyroscope and acceleration (x, y, and z) of the ISS by way of accelerometer. We then compared the data gathered by the IMU sensor to the position data (latitude and longitude) processed on Earth in the forms of R, Theta, and Phi to try to design a multi-dimensional linear regression line. Before comparing the data, we used mean normalization to allow the data to have zero mean and variance for the sake of better visualization and less predicting bias.

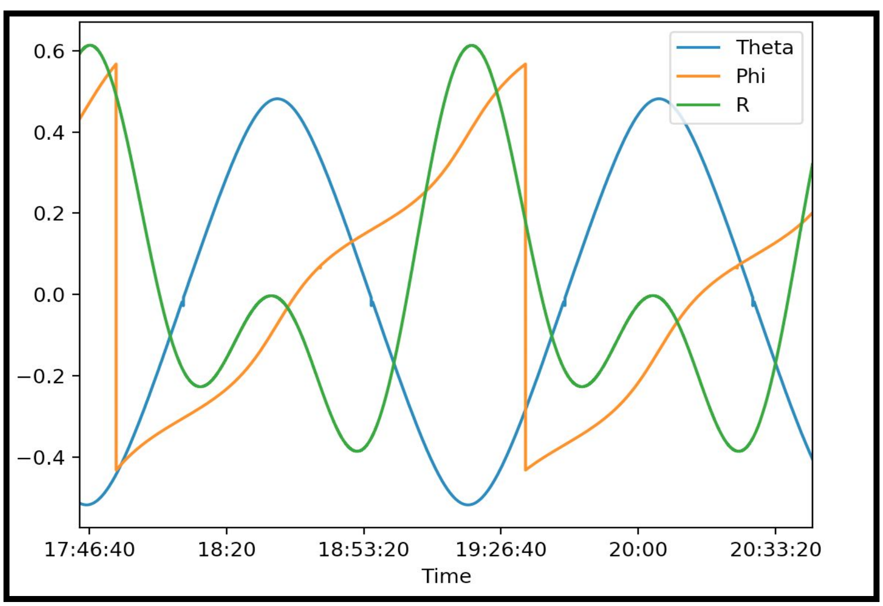
(Link to the source code of the Machine Learning algorithm, which predicts the location of the ISS based on the historical data: https://bit.ly/30Vhtyt)

Figure 1: Tensorflow Graph representing the Machine Learning algorithm

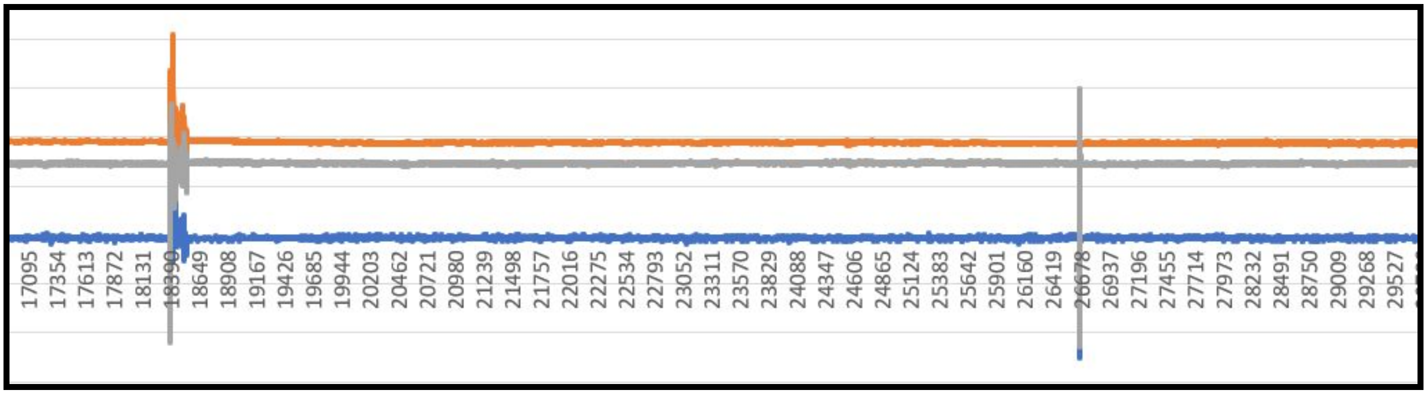


Results

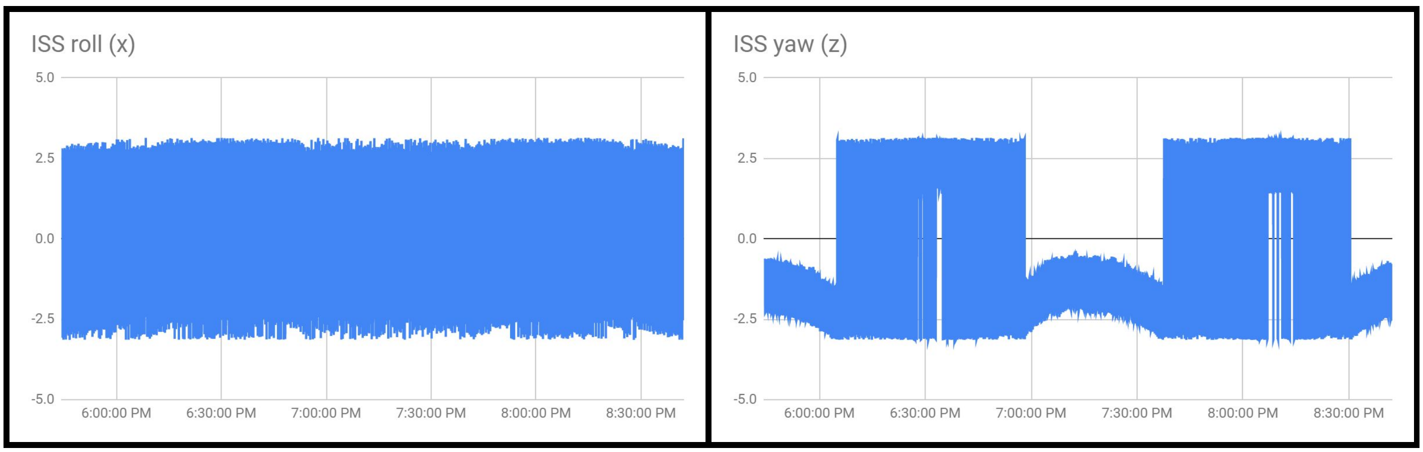
Figure 2: R, Theta & Phi Vs Time Graph



<u>Figure 3</u>: Acceleration Vs Time Graph



<u>Figures 4 and 5</u>: ISS Roll and Yaw vs. Time Graphs



Our group found that the latitude (Theta) of the ISS was always between -51.62º and 51.62º. Similarly, the longitude (Phi) of the ISS was consistently between -180º and 180º. In Figure 2, we can demonstrate this discovery through the interpretation of sinusoidal curves that oscillate in a repeating pattern. Furthermore, the acceleration data illustrates instances in which the acceleration of the ISS experienced a significant change. In Figure 3, we can see how there are two large spikes, which we initially interpreted as being re-boosts since the ISS accelerated at a fast pace. However, we then became aware that these changes of velocity were only 30 minutes apart from each other, which does not support the claim that these spikes represent re-boosts, since re-boosts only tend to occur every 30 days. Additionally, our group struggled finding any relevant correlations in Figures 4 and 5, due to the massive oscillations of the data. The roll (the X position of the gyroscope) was constantly alternating between -2.5 and 2.5 radians, which is a 143° rotation every second. The Z coordinate showed similar variances, but it repeated after 90 minutes (the ISS' orbit duration).

Conclusion

Our group conducted this investigation to develop a system that would accurately calculate the position of the ISS relative to Earth. The data gathered was incredibly interesting and unexpected at times. The data graphed in Figure 2 supports the initial prediction that the latitude and longitude of the ISS would be essential to predict the position of the ISS. This is because when the variables were graphed after having undergone the process of mean normalization, they resembled sinusoidal functions that could predict the position of the ISS. Initially, we interpreted the acceleration changes in Figure 3 as an indication of a re-boost. However, after conducting further research, we discovered that re-boosts only happen once in every thirty days, thus indicating that the acceleration on the graph does not represent that caused by a re-boost. We are now interested in analyzing what caused the acceleration present in Figure 3 and what would have happened if the SenseHat’s sensor would have captured the effects of a re-boost on the acceleration of the ISS during the hours three of data collection. In the future, our group would be interested in developing a system capable of tracing a real-time trajectory of the ISS.