The Use of Artificial Intelligence in High Altitude Balloon Flight Path and Landing Predictions

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Abstract

The goal of this research project is to create a predictive model that can be used with artificial intelligence to predict the flight path and landing zone of a high-altitude balloon.

This will be done by first creating approximation data using calculus to act as a baseline for the model. The model will then be corrected and tuned until the amount of bias/error has been reduced to an acceptable level. Once this initial model has been established, real world flight data will be introduced to determine its accuracy. At this point potential machine learning algorithms will be considered.

The predicted result of this project is that a viable model will be produced that can be used with artificial intelligence in the prediction of the flight path and landing zone of high-altitude balloons. If the results of this research are positive, then the use of artificial intelligence could aid in ensuring the safe flight of high-altitude balloons.

Methods

Making a testing spiral: The first step of this project was to create a testing spiral using a polar formula in Python. This spiral would be used as the ideal to compare the accuracy of our model in later stages.

Generation of approximation data for testing: Two functions were defined to plot the position of a spiral given in polar form. Then, standard calculus was used to differentiate the data to create functions for the velocity. Next, in order to create simulated accelerometer data, the central difference method was used.

Finding simulated position data: The generated accelerometer data was then integrated twice using the trapezoidal rule. This gave simulated velocity data on the first integration and simulated position data on the second. This data was then graphed and compared to the test spiral.

Tuning of the model: The initial model test showed a quick increase in bias/error, so some corrections were needed. The amount of error for the x-position had a large jump early which was unexpected. After evaluation, the problem was found to be the use of uniform time rather than elapsed time. Once this was corrected, the amount of bias was within the expected parameters.

Use of model on real world accelerometer data: The next step in the process was to test the model on real accelerometer data. The data was taken from a previous high altitude balloon flight. This data was graphed at each stage. The real world acceleration data was entered into the model which produced a position. The final data point for position was compared to the landing spot of the actual flight.

Final step: The final step in this project was to determine if it is possible for machine learning algorithms and artificial intelligence to correct the produced model. This was done by looking into various methods used in machine learning and artificial intelligence.

Results

Figure 1. Generated accelerometer data

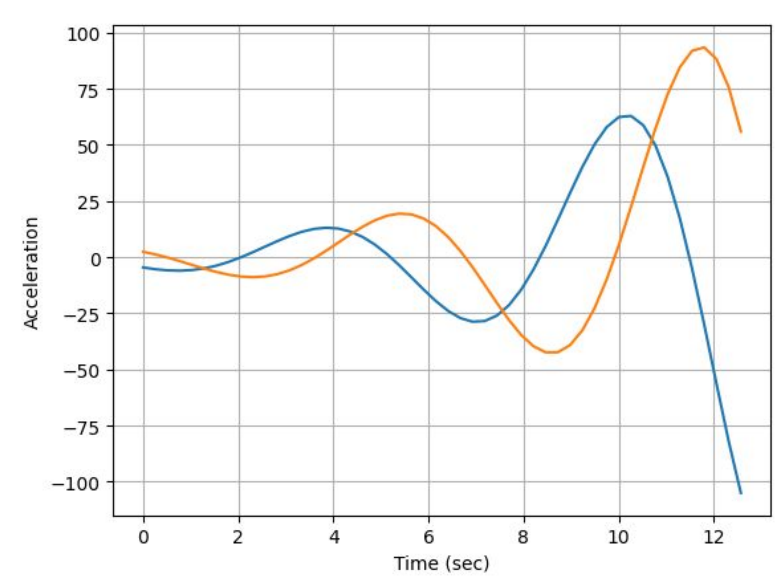
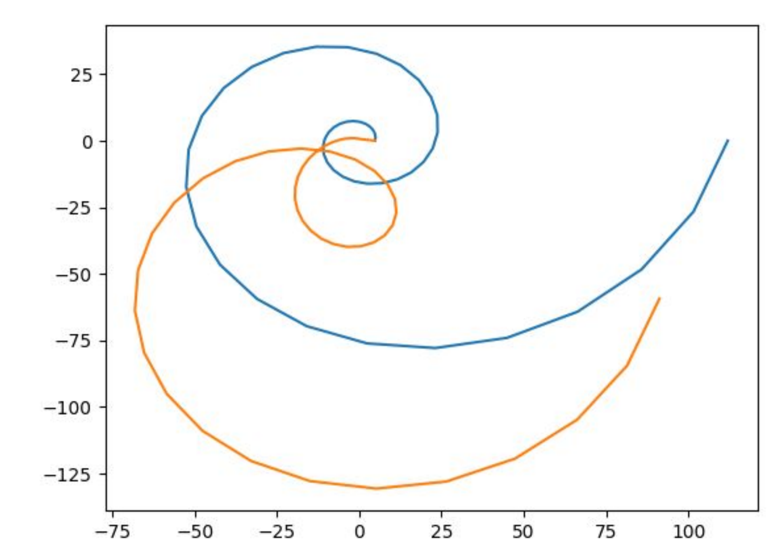
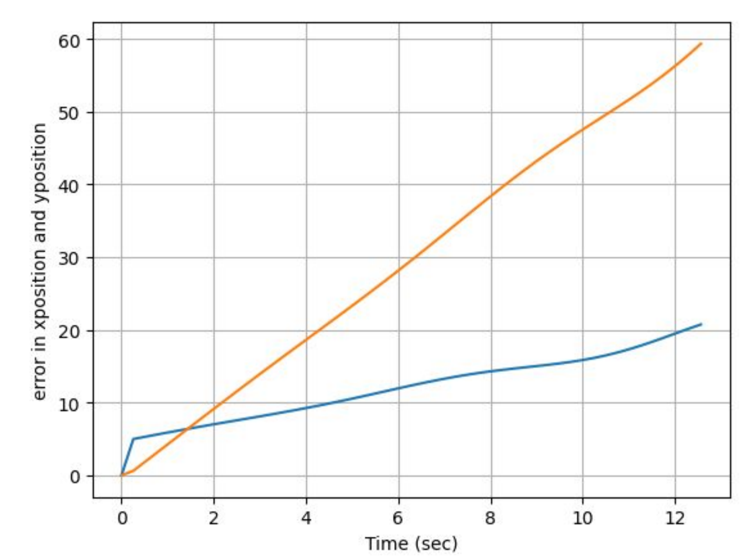


Figure 2. Simulated position data vs. testing spiral



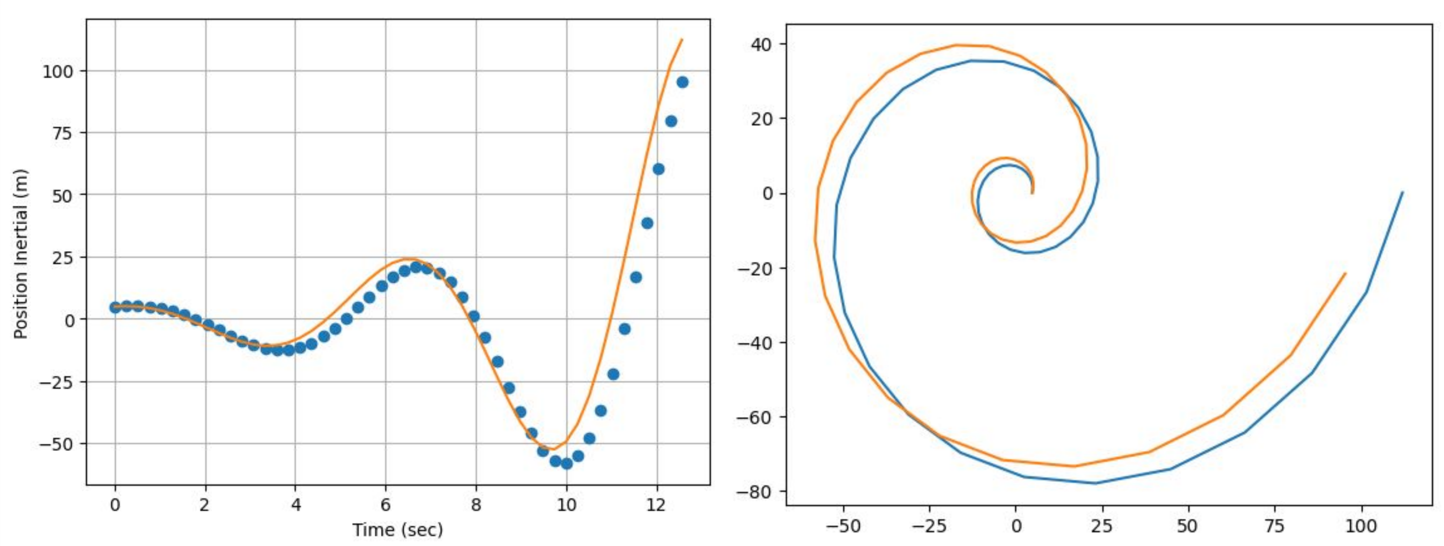
Results: The bias/error in the generated data grows rapidly from the start. Some corrections to the model were needed to reduce this.

Figure 3. Graph of error in the x-position (blue) and y-position (orange).



Results: The large jump in error in the x-position was unexpected. This would need to be reduced

Figure 4. New simulated position data vs. testing spiral



Results: After correcting the model to incorporate elapsed time, the data became more accurate for a much longer period of time.

Figure 5. Graphs of real world accelerometer data before and after passing through the model.

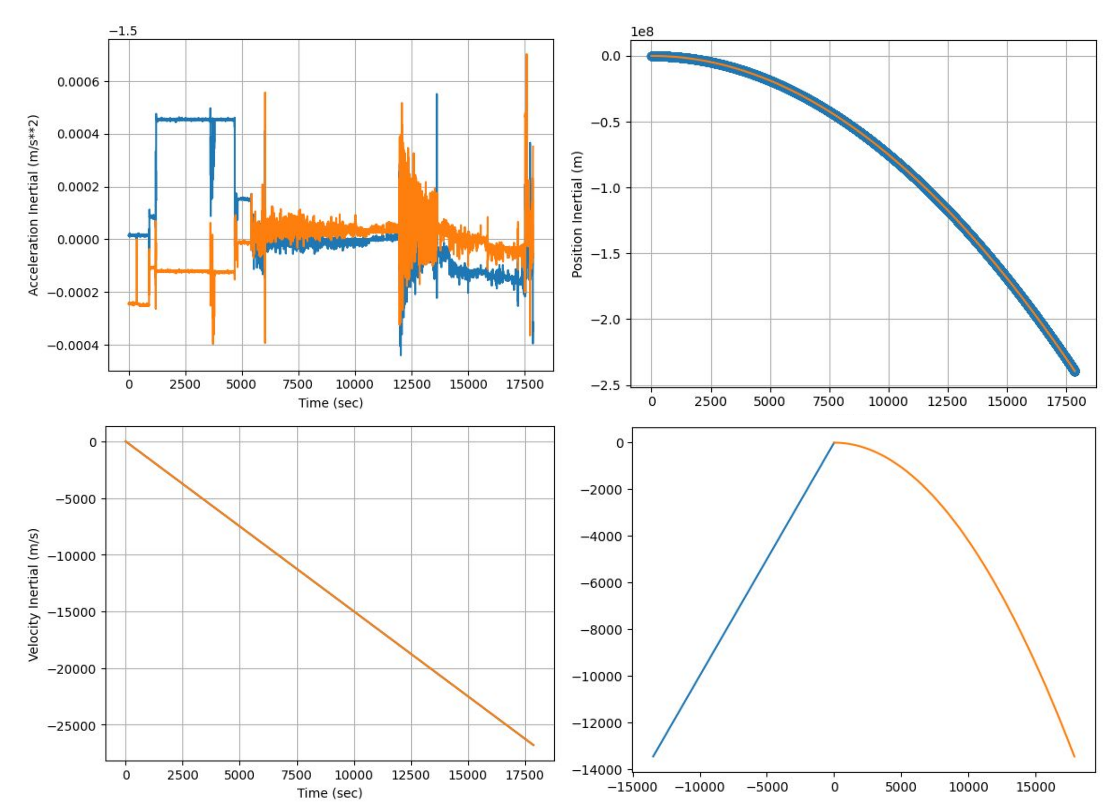
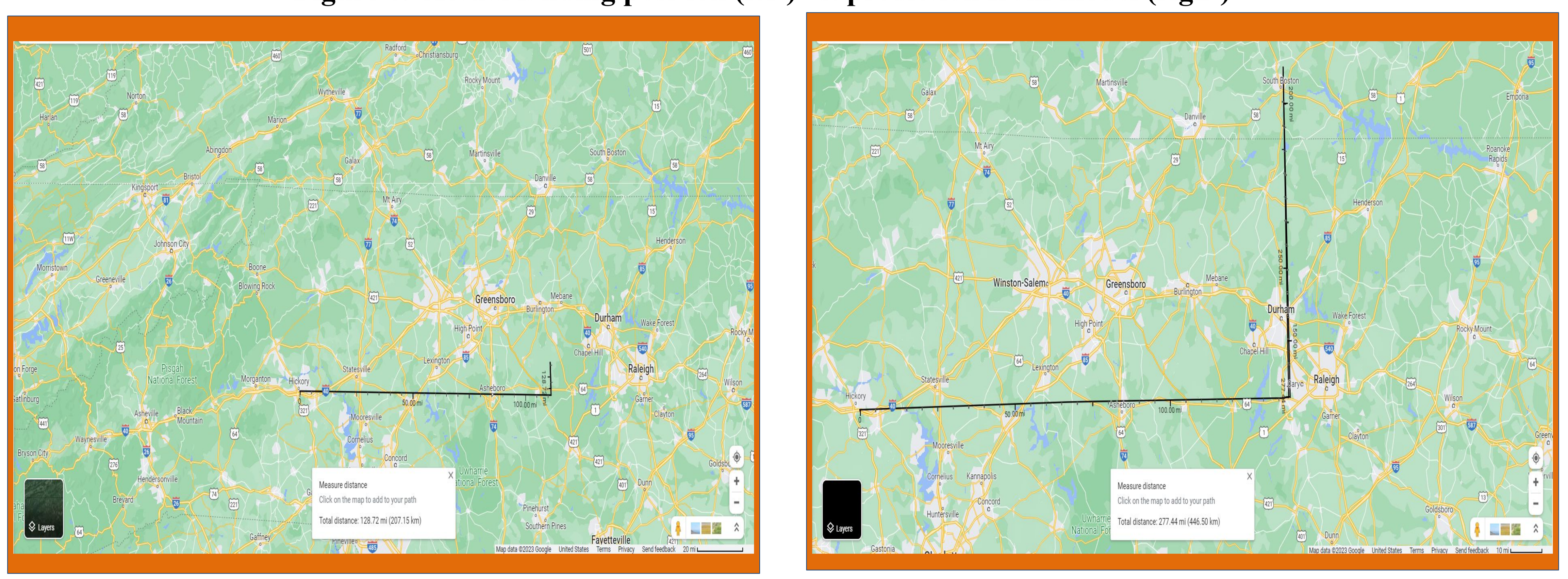


Figure 6. Actual landing position (left) vs. prediction from model (right)



Results: The position predicted by the model was only 10 km off the x-direction but was 200 km off in the y- direction. There are several possible explanations for this large jump, but the two most likely are either a large bias event that happened at some point in the y calculations or the accelerometer itself was rotating such that the y- axis became the z-axis at some points during the flight. Further testing would have to be done to determine the exact cause of the error.

Conclusions

The process of creating the predictive model was the main focus of this project. While the bias/error in the approximation accelerometer data was corrected to closely follow the path, when real flight path data was used, the bias/error was increased. This error had several possible causes, but further testing would have to be done to determine the exact cause of the error. The predicted landing zone was within range of the x -direction prediction, but the y-direction was 200 km off position. At the end, the model was in a position to be corrected by artificial intelligence once a suitable machine learning method is determined. Potential machine learning and corrective models were found, with the leading option being the use of stochastic models with machine learning to correct the predictive model.

Future Directions

- Determine the exact cause of the incorrect prediction of the landing zone.
- Determine what machine learning algorithm will be best for the final model
- Use of machine learning algorithms in the creation of artificial intelligence that can correct bias/errors in the model.
- Test the artificial intelligence with the prediction of a future high altitude balloon flight and determine the accuracy of the results
- Finalize the artificial intelligence with needed corrections to its predictive model.

Acknowledgements

- North Carolina Space Grant
- CCC&TI HAB-C Team Karman Seekers: Gave access to accelerometer and flight data

- Doug Knight, Joby Cook
- Lucas McGuire, Denise Williams: Mentors
- Joseph Mel Rhoney Jr.: Major help with all math and programming
- Gloria Rhoney: Helped with poster design