University of Colorado Boulder

ASEN 3801: Aerospace Vehicle Dynamics and Controls Lab

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ASEN 3801 LAB 2: Notation, Orientation, Rotation Matrices, and Direction Cosine Matrices

Team 40

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Description	ASEN 3728 Notation	ASEN 3700 Notation
The inertial position of the vehicle expressed in body coordinates	p_b^E	${}^I r_b$
The inertial velocity of the aerospace vehicle in body coordinates	V_b^E	${}^I \dot{r}_b$
A vector in inertial frame which connects the points I and A	$p_{I/A}^E$	${}^I t_{IA}$
Rotation matrix which relates Body coordinates to Inertial coordinates	R_E^B	Q_B^I
The velocity of the aerospace vehicle relative to the target, expressed in inertial coordinates	V_E^T	${}^I \dot{r}_T$
The rotation matrix which relates A coordinates to B coordinates	R_A^B	Q_A^B

2

During the data collection process, the aerospace vehicle rises and then moves in a rectangular shape. The aerospace vehicle then moves in a complete circle, then reverses direction and moves in circles while gaining altitude. It then lowers directly back to the ground. The target starts on the x-axis marked on the floor (from the perspective of the video) and begins by walking in a rectangle, then walks in a semi-circular motion. She walks in a small diagonal motion, then a large diagonal and then walks in a straight line to the y-axis marked on the floor. During this process, when the target walks parallel to the x-axis, the aerospace vehicle moves in the same direction. When the target walks parallel to the y-axis, the aerospace vehicle moves in the opposite direction. When she walks in a semi-circular motion, the vehicle moves in a circle at a constant altitude. When she walks in diagonals, the aerospace vehicle moves in circles while increasing altitude.

3

3a. The LoadASPENData function takes in the target and aerospace vehicle position and attitude data, cleans the data with the ConvertASPENData function, and organizes the data into matrices that can be operated on. Before loading the data in, the file was cleaned by removing title and space columns.

3b. The RotationMatrix321 function takes in 321 Euler angles and returns a 321 rotation matrix.

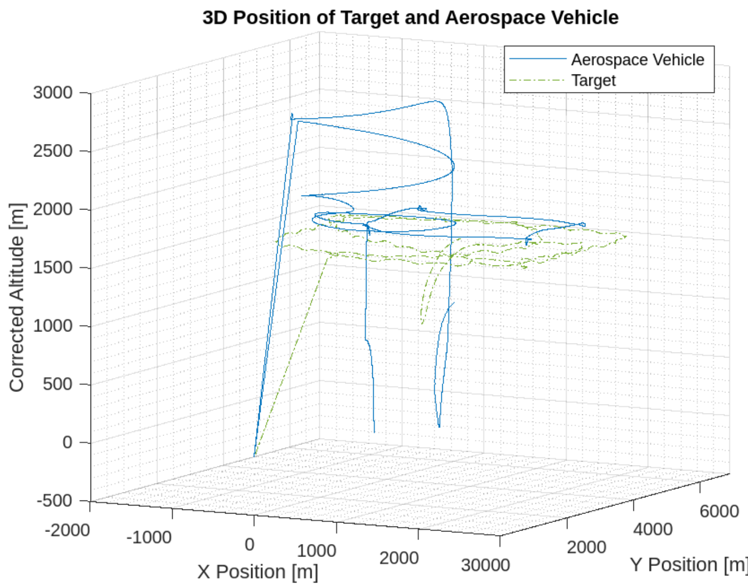
3c. The RotationMatrix313 function takes in 313 Euler angles and returns a 313 rotation matrix.

3d. The EulerAngles321 function takes in a 321 rotation matrix and returns 321 Euler angles.

3e. The EulerAngles313 function takes in a 313 rotation matrix and returns 313 Euler angles.

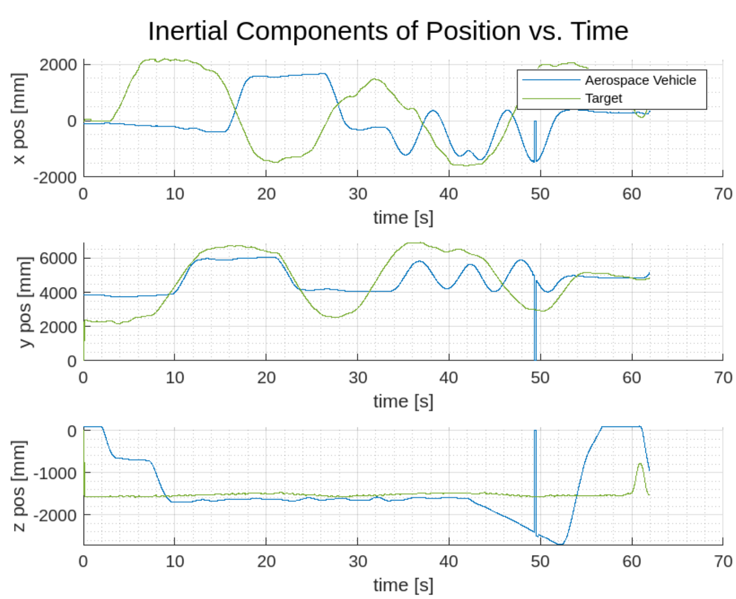
4a

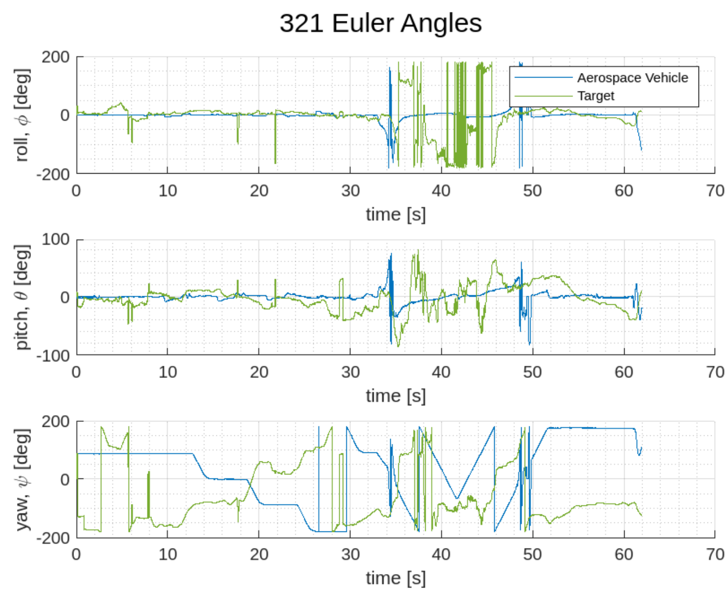
The solid blue line on the plot represents the motion of the aerospace vehicle. The solid line implies that the aerospace vehicle keeps to a constant trajectory while gathering data. The dashed green line on the plot indicates the target's motion as it is a bit more turbulent and discontinuous due to the tracking cameras collecting data from anything shiny that may have been near the target. The sudden dips to zero in the data are places where data collection was skipped, leaving an empty row in the data file. These empty rows were replaced with zeros, causing the trajectory graphs to have sudden dips to zero.



4b

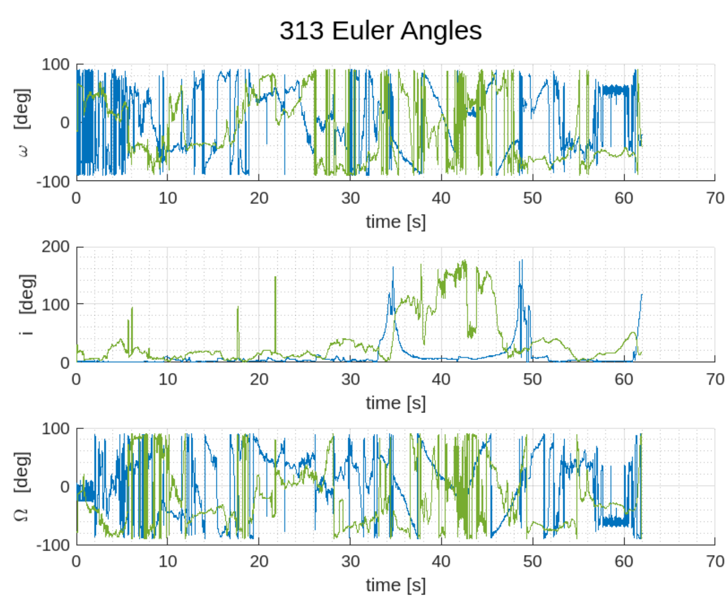
The aerospace vehicle (blue) and the target (green) both have subplots for position versus time and Euler angles vs time. From these subplots, we can analyze how the positions and orientations of both objects evolve over time. With the position versus time, it's easy to see how it correlates with the three dimensional trajectory plot in 4a. With the Euler angles versus time, it's a little harder to understand, but from watching the video of the aerospace vehicle and target moving, the angles make sense. One thing on the Euler angles versus time graph that doesn't seem to make sense at first glance are the drastic changes from roll angles of -180 degrees to 180 degrees. However, there are some discrepancies in the data collected that cause these drastic changes, as well as with how MATLAB processes and plots those discrepancies.





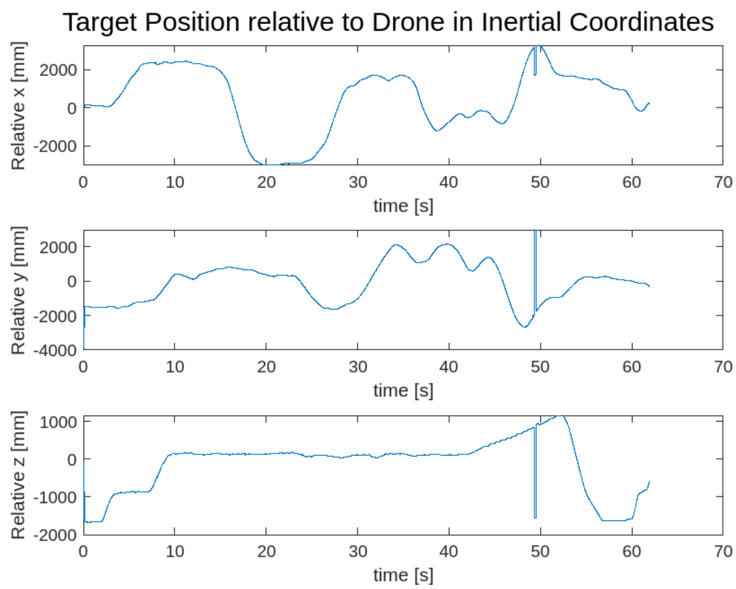
4c

The orientation of each object in relation to the inertial reference frame is described by the 3-1-3 Euler angles. The subplots show how these angles alter over time for both objects. This allows us to understand the orientation of each object as it moves through space.



4d

The relative position of the target with respect to the aerospace vehicle in inertial coordinates is shown by these subplots. These plots are similar to the plots in 4b because the position of the target in inertial coordinates doesn't change here other than the fact that the position is with respect to the aerospace vehicle rather than the inertia frame. In other words, the inertial position of the aerospace vehicle was subtracted from the inertial position of the target, resulting in these subplots.

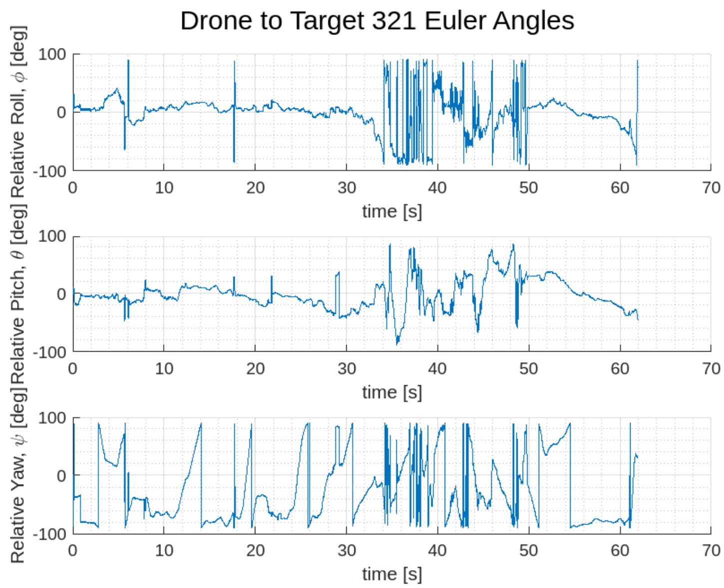


4e

This subplot displays the target's position in relation to the aerospace vehicle, but this time in terms of the aerospace vehicle's body coordinates (Frame A). We can better understand how the aerospace vehicle sees the target's position by examining these components. These subplots are similar to those of 4b and 4f, however, the position of the target relative to the aerospace vehicle has been rotated from inertial coordinates to the aerospace vehicle body coordinates.

4f

The transformation from the aerospace vehicle frame to the target frame is represented by the direction cosine matrix (DCM). The parameterization of this DCM uses the 3-2-1 rotation angles. We can see how the orientation relationship between the aerospace vehicle and the target varies over the course of data gathering by graphing these angles against time. This allows us to understand the alignment between the two frames and how they are dependent on each other.



Acknowledgments

0.1 Member Contributions

Team Participation	Plan	Model	Experiment	Results	Report	Code	ACK
Paige Catena	1	1	1	1	2	1	x
David Mcgraw	1	1	1	1	1	2	x
Rishab Pally	1	2	1	1	1	1	x
Sierra Vesey	2	1	1	1	1	1	x