Aerodynamic Modeling of an Aerobot for Exploration of Titan:

July Progress Report

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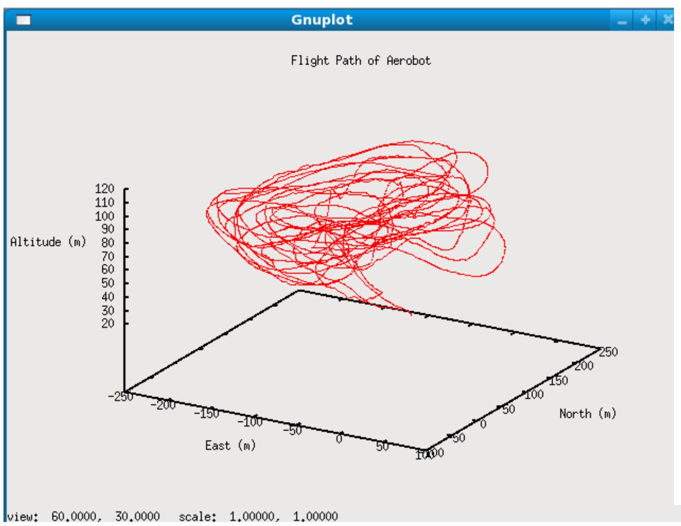
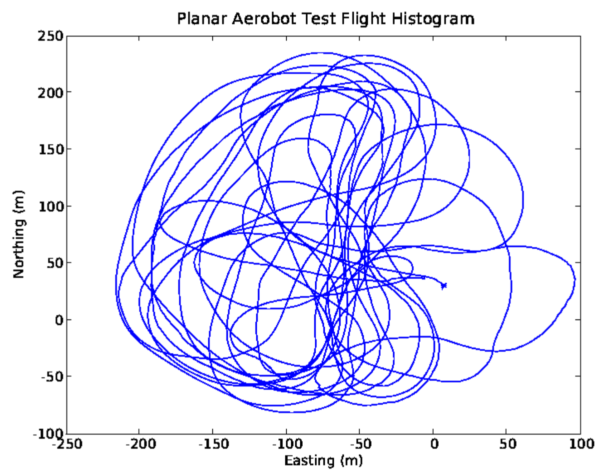
The motivation for sending an aerobot mission to Titan is a culmination of examining valuable scientific targets located on Saturn's moon and the valuable experience gained in undertaking a feat so great. Astronomers and scientists have long since pondered over the surface of Titan as it was veiled in a thick clouded atmosphere until the Cassini-Huygens 2004 mission began to reveal the mystery. It was this mission which first began to record data regarding the surface of Titan; However, this proved to only increase the questions and curiosities surrounding Saturn's largest moon. There is now significant data showing open bodies of liquid hydrocarbons, boulders composed of water-ice, and geological features startlingly similar to those of Earth [1]. In addition, the shear complexity of the mission, as with any unprecedented challenge, would further improve our understanding of the universe of which we are a part and would heed our human instincts to explore and inquire. All of the above provide ample justification and motivation for an in depth exploration of Titan for which an aerobot is best suited due to its high mobility and low energy requirements [2].

Until now the lab has performed the first crucial steps in the modeling and analysis of the aerobot. A beginning framework for the aerodynamic model has been formulated and programmed. Additionally, two preliminary test flights have been performed and a small cache of test data has been accumulated which will be crucial in validating the fully developed aerobot model. The validation of these models is priority because any aerobot mission to a target such as Titan would require a significant amount of autonomy due to the large communication lag, the dynamic wind fields and weather patterns, as well as the relatively unknown environment [3][4].

The specific problem being addressed by my SURF project is the creation and validation of a robust aerobot model. This requires an accurate aerodynamic model to be coded on the computer such that one can view how the aerobot would react to aerodynamic forces, control surface inputs, thrust vectoring, and wind-fields which will be encountered. This model will come from the basic equations of motion and aerodynamic laws and then will draw upon the gathered real world flight data from aerobot testing. Another part of the task to be completed includes the creation of automated software to expedite the process of data massaging for model validation.

In the past week and a half I have spent much of my time getting further acquainted with the project goals and environment. As with any software related task where some framework is already in place it is a significant task to simply become familiar with the existing Application Programming Interface (API). Following that, I have successfully gotten many automated testing applications functional which can be run throughout development to ensure the models are producing consistent results. Currently I have begun and nearly completed a small data parsing script to help automatically interpret the data brought back from past and future flight tests. The following are two sample plots generated by my script representing the flight path of the aerobot during a previous test flight.





All of this has been in conjunction with readings and research to better understand the dynamics of airships and their modeling. In particular, the specific characteristics of modeling and airship as compared to traditional fixed-wing aircraft and their general control handling behavior. [5]

The following month with require a significant amount of work in the area of improving the existing computer model of the airship. This entails analyzing the underlying physics and making the computations more robust for all variety of input scenarios. Additionally, the team is expecting to make another flight test in the month of July, so I will be devoting some time to the preparatory work for the launch and the collection of data. This will require an assessment of the planned experimental procedures to ensure that the methodology to be followed is feasible and will realize the maximum amount of useful results for the minimum flight time. Prior to this, I will be performing additional preparatory work for the analysis of the gathered data so that once collected it can be efficiently and automatically analyzed. This will greatly improve the time it will take to insure the fidelity of the models being constructed.

As of yet, the most significant challenges that I have faced have been related to getting up to speed with the work that has already been accomplished and the programming APIs mentioned. The primary challenge that is expected to be faced is the time limitation in the coming months. Assessing the fidelity of models is a time-consuming process but it is such a necessary component in these early stages that it should not be cut short. The process itself is expected to be a significant challenge simply because the test data is being gathered in an uncontrolled environment and we need to adapt our models to fit accordingly. If the tests were being flown in wind-tunnels many more uncertainties could be eliminated to provide more reliable results. Because this is not an immediate option, we must design the flight procedures so as to minimize any uncertainties or errors caused by everything from wind field variation to atmospheric conditions. This is the essence of verifying aerodynamic models though, and must be completed with diligence.

The required resources to complete this agenda of tasks is quite minimal as it is primarily completed on the computer. However, in order to substantiate the results computed by our models, we will need the actual aerobot to be flown in a test scenario. This is a significant use of time and assets that will need to be expended before further steps are taken in the research.

The project is progressing well and we are anticipating many valuable results from its contribution. With the current projections and pace of work, a completely functional model should be produced before the conclusion of the summer and it validated to the extent allowed by the gathered data.

References

[1] NASA Jet Propulsion Laboratory, California Institute of Technology, “Cassini-Huygens: Moons,” http://saturn.jpl.nasa.gov/science/moons/moonDetails.cfm?pageID=16

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[3] J. L. Hall, V. V. Kerzhanovich, A. H. Yavrouian, J. A. Jones, C.V. White, B. A. Dudik, G. A. Plett, J. Mennella and A. Elfes, "An Aerobot For Global In Situ Exploration of Titan," *35th COSPAR Scientific Assembly*, Paris, France, July 20-24, 2004.

[4] A. Elfes, J.F. Montgomery, J.L. Hall, S.S. Joshi, J. Payne and C.F. Bergh, "Autonomous Flight Control for a Titan Exploration Aerobot," *In 8th International Symposium on Artificial Intelligence, Robotics and Automation in Space*, September 2005.

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