Model of Aerodynamic Activity with Variations in Airfoil Design

New Mexico

Supercomputing Challenge

Final Report

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Team 86

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Executive Summary

To model aerodynamic effects on an aircraft's wing, we have created a virtual wind tunnel through the NetLogo programming language. Our simulation includes a wing with air particles advancing across the screen, avoiding the wing as they do so. This simulation has made it relatively easy to show how individual air particles behave as they are pushed and manipulated by an airfoil. We have been able to model properties such as current flow in the wake of the wing's path and Bernoulli's Principle. We have tested many different shapes and arc lengths of the wings tested, and have found better possible wing shapes that might allow for developments in engineering of an aircraft to sustain more stability or speed during flight. More powerful engines could be placed on wings built in this fashion to allow for greater capabilities during super-sonic flight within our atmosphere.

Model of Aerodynamic Activity with Variations in Airfoil Design

Airfoil designs have been altered and improved throughout history to yield different results and qualities. Since the first flight and concepts over 100 years ago, we have evolved from bi-plane designs, such as the Wright Flyer, to delta wing aircraft, such as the Dassault Mirage III and Space Shuttle. While the airfoils in use today are efficient enough to allow for incredible speeds and capabilities, they are not efficient enough to imagine a world where commercial, military, or recreational flights could include time outside the atmosphere or in low orbit. Rockets are currently necessary for an aircraft to reach possible escape velocity (25,054 mph). If airfoils were improved to near perfect efficiency, a large jet engine would be very capable of propelling aircraft out of our atmosphere, and into orbit.

Our project was aimed towards improving the design of such airfoils so that they may be efficient enough to make the use of more powerful engines practical. We may change how we think of airfoil designs to the point of expanding the field of Aerospace Engineering to encompass ideas such as intra-atmospheric ion engines. We have been able to maximize some properties that have been identified as beneficial or necessary to the flight of the aircraft, while minimizing the properties that will impede the airfoil's motion through the atmosphere.

Method:

We used NetLogo to model how present properties of airfoils, specifically Bernoulli's principle and air resistance, allow for and affect flight. Using this information, we were able to accurately simulate how the airfoil moves through the atmosphere. We aimed to record data such as how many particles have passed under and over the wing, as well as what kind of drag or friction was created. Numbers of particles passing by the wing were easily calculated and helped to model Bernoulli's Principle because the principle states that the faster a fluid is flowing, the less pressure it exerts. We simply measured how far the agents travelling the arc of the top edge of the wing were behind the agents travelling the shorter distance along the bottom edge. Friction was not a feasible aspect to represent by our simulation because we could not find a way to accurately represent it within the model. Existing information from research done on friction will have to be adapted to relate to the speeds we wish to represent with this program.

Validation and Verification:

Graphs retrieving data from the simulation will be present on the interface of our simulation as it is running. These graphs will be retrieving data such as the distance of the particles on top of the airfoil to the particles on the bottom of the airfoil, and how many particles are passing by a certain point in a set time-frame. These graphs will provide us with necessary information to calculate pressures exerted at different times during flight, and different values for other mathematic calculation.

An existing program simulating wind tunnel conditions was used to analyze airfoil designs that would yield promising results for the simulation. This program is not as finely mathematically tuned as the program we have created through NetLogo, but it was made to show accurate representations of particles within a large wind tunnel. The program was used to find testable airfoil designs as a preliminary procedure, as well as to verify that the particles in our program were behaving as they should in real situations.

Acknowledgements:

Our teacher Alan Daugherty has been an invaluable part of this project. He has shared his knowledge on the NetLogo program, as it is our first year using this program, and guided us in achieving the goals we set before ourselves at the beginning of the year.

We used the program Wind Tunnel Pro HD (Algorizk, 2013) to analyze airfoil designs prior to testing them in our NetLogo simulation, and to verify that our program was behaving correctly. We do not take credit for this program. All rights belong to Algorizk.