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Design and Development of an Online Wind Tunnel for the Aerodynamics Lab

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Project Summary:

Traditional hands-on aerodynamics laboratories are educationally effective for illustrating complex aerodynamics concepts taught in lectures. While they add an active learning component to courses, they also impose significant space, time and personnel costs on the educational institutions and they it is usually difficult to convert to online teaching. These costs can be significantly reduced by using virtual laboratories. This project aims to develop an online wind tunnel laboratory, which combines real-time remote access to an actual wind tunnel located in N139 OKT building with a software-based virtual wind tunnel.

A Wind tunnel is a device for producing a controlled stream of laminar flow of air in order to study the effects of movement through air or resistance to moving air on models of aircraft and other machines and objects. Provided that the airstream is properly controlled, it is immaterial whether the stationary model under testing is designed to move through the air, as an aircraft, or to withstand wind pressures while standing in place, as a building. There are two main types of wind tunnels in terms of the design, the open-circuit and the closed circuit and each type is chosen based on the use of the tunnel. Wind tunnels are among the most important design tools used in engineering to study the effects of air moving over or around solid objects such as airplane wings, cars, trains, skyscrapers, bridges, etc. While introducing wind tunnels to engineering students as part of their laboratory experience in MAE 331 course contributes to improving their understanding of fundamental fluid mechanics concepts, the significant equipment cost renders the student use of wind tunnels in a traditional hands-on mode is infeasible for most educational institutions. At UAH we have three subsonic wind tunnels and one supersonic wind tunnel and two of those are available to students for educational purposes.

The remote experiment system will allow the students to explore the air flow patterns around various objects (bluff bodies, airfoil wings, etc.) the orientations of which can be controlled interactively. This experimental setup aims to provide the students with real-time measurements for pressure, velocity and drag force in conjunction with streamed audio and video. These remote experiments can be complemented by virtual experiments, in which the shape, size and orientation of the physical objects available in the remote setup can be modified or these objects can be replaced entirely by other objects for which no physical models exist. The students will be able to gain confidence in the validity of the software simulations through comparisons of the

simulation results with data from actual hardware-based experiments.

The RCEU student's tasks in the project include:

i.) Familiarization with wind tunnel testing
ii.) Development of a user-friendly graphical user interface (GUI) in MATLAB iii.) Build a PID controller to conduct various automated tasks in the wind tunnel iv.) Test the final system and validate performance

Student Prerequisites

The student will be required to have the following skills:

i.) Basic understanding of fundamental aerodynamics concepts and related sciences
ii.) Sufficient knowledge and experience in MATLAB, LabView
iii.)Basic understanding on PID controller
iv.)Minimum GPA of 3.2

Student Duties and Deliverable

This project requires the student to use analytical and observation skills in a laboratory setting. One big aspect of the project will entail the use of software to simulate and manipulate data. In weekly meetings, the student will give progress reports to the mentor and discuss current progress. A final report will be submitted during the 10^{th} week for the mentor to evaluate. Provided is a tentative 10-week project schedule:

Week 1: Introduction to both lab, equipment, and background.
Week 2: Review literature on online wind tunnel development.
Weeks 3-4: Develop a GUI for the operation of the wind tunnel remotely.
Weeks 5-7: Develop a controller and integrate with the wind tunnel
Weeks 8-9: Conduct tests to validate the developed system
Week 10: Analysis and documentation of the system

Mentor Supervision and Interaction

The research mentor will have regular interactions with the RCEU student during the project period. Undergraduate students will also interact with graduate research assistants to facilitate a more productive environment. The instructor/research mentor will confer with the student in regularly scheduled, weekly meetings to supervise, mentor, evaluate progress and assess student's general project development and work product.