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Development of an Educational Cost-Effective Particle Image Velocimetry System

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RCEU 2022 Project Proposal

Project Title

Development of an Educational Cost-Effective Particle Image Velocimetry System.

Faculty Information

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Previous participation in RCEU: Yes

Project Summary:

Particle Image Velocimetry (PIV) is used to measure the instantaneous velocity field in a planar cross section of the observed flow. With PIV the fluid velocity is determined by measuring the displacement of small tracer particles over a small time interval. Current PIV systems are known to be dangerous due to the need for high-energy lasers and require precise imaging optics and proprietary software. Thus, due to cost, size and safety concerns, they have limited application within educational environments. Only a few educational PIV systems exist today, but most require either the use of proprietary software or high-powered industrial lasers. I propose to develop an inexpensive and safe PIV system for an educational setting that only trades off some of the accuracy compared to industrial PIV systems. Using a low-power light source results in diminished brightness that prevents adequate particle illumination (reduced accuracy); however, it makes the system safe to operate with adequate accuracy for educational purposes. Students' individual smartphones will be used for data collection, and open-source software (openPIV/ JPIV) will be used for data processing. After the systems are developed, they will be distributed to regional high schools that have agreed to collaborate with us and their mission is to equip students through advanced studies and global industry experience in STEM field. The incentive of developing a mobile state-of-the-art system is to lay a good foundation of knowledge and robust understanding of fluid mechanics early in student's education, which will later in college be a critical success factor within all engineering fields.

The RCEU student's tasks in the project include:

i.) Familiarization with wind tunnel and PIV testing
ii.) Development of a user-friendly graphical user interface (GUI) in MATLAB
iii.) Design an experiment for testing
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 and Python
iii.) 3D printing skills
iv.) Minimum GPA of 3.5

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 PIV systems.
Weeks 3-4: Develop a GUI for the operation of the wind tunnel remotely.
Weeks 5-7: Develop an experiment and collect data
Weeks 8-9: Conduct tests to validate the developed system
Week 10: Analysis and documentation of the results

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.