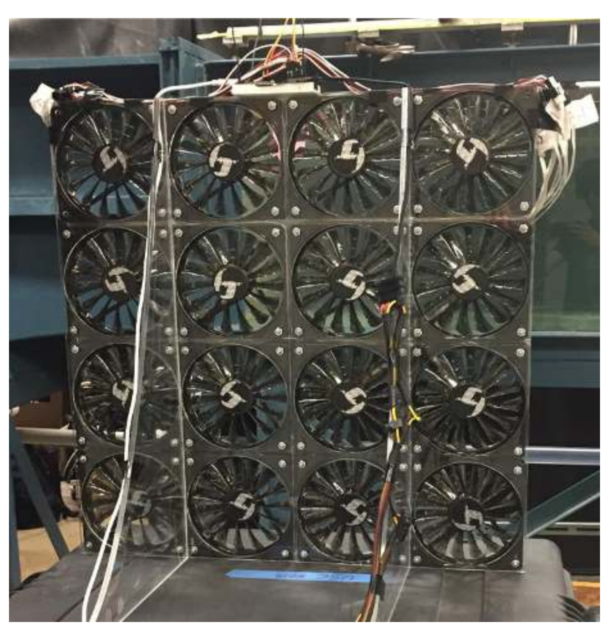
Developing a Computer-Controlled, Turbulent-Flow Wind Panel

Sarah Fry, sarahr19@mhs-la.org
Marymount High School, Class of 2019
USC Viterbi Department of Aerospace Engineering, SHINE 2018

Introduction

- Dr. Mitul Luhar is investigating the aerodynamics of small objects, especially in situations of gusts or turbulence.
- While a typical wind tunnel allows for the observation of aerodynamic performance in laminar (straight, predictable) flow patterns only, through this project we designed and constructed a wind tunnel capable of producing turbulent patterns (*see below*).



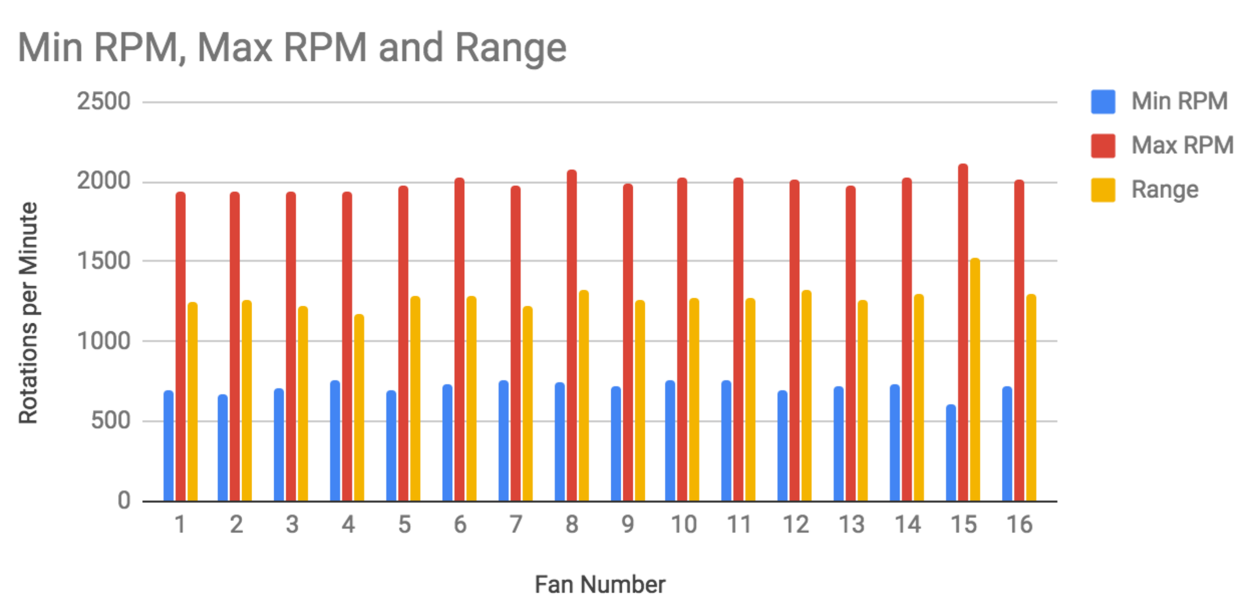
Our Fan Array

Relation to STEM Coursework

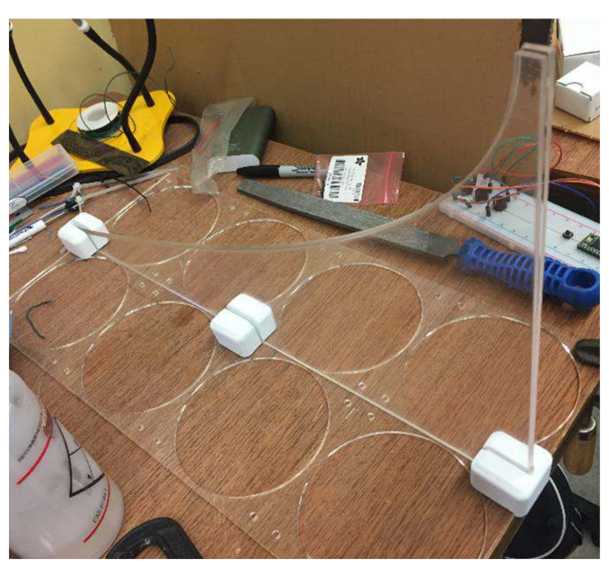
- This project relates directly to principles of electricity and electronic circuits covered in physics and chemistry classes, though this project focused on applying rather than simply learning these concepts.
- This project also placed a heavier emphasis on programming and software than I have experienced in typical classroom settings.

Project and Experiment Specifics

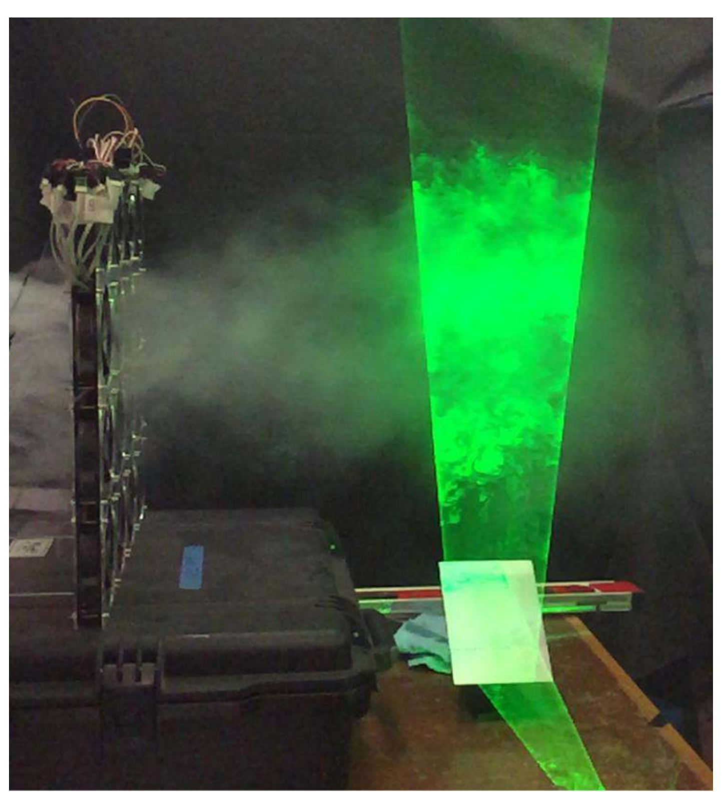
- My partner and I designed a fully-programmable, small-scale wind-producing panel with an array of 120-millimeter computer fans.
- The fans are operated by microcontrollers, specifically a Teensy (*see Fig. 4*) and an Adafruit 16-channel PWM Servo Driver (*see Fig. 5*).
  - We used the teensy to install programs to operate groups of fans at varying speeds.
  - The Adafruit 16-channel PWM Servo Driver functions to translate and carry these commands to the fans.
- To ensure standardization throughout the array, we evaluated the RPM range for all fans by measuring their tachometric signals before installing them (*see bottom left*).
- We utilized Solidworks software, laser cutters and 3D printers to design and create a robust, effective casing for the fan array as well as a practical wire management system (*see center*).
- We used technology called Particle Image Velocimetry (PIV) to visually map variances in the velocity of the fans' airflow in two dimensions (*see bottom right*).
  - We tested both windshear and uniform flow patterns.



RPM Range Data



PIV Testing



Fan Casing Construction

Skills Learned

- Basic principles of aerodynamics, specifically flow straightening
- Programming skills in Arduino software and usage of microcontrollers
- Details of communication protocol between microcontrollers and actuators
- Part construction and assembly using Solidworks software
- Electronic configuration and anatomy of small-scale integrated circuits
- Operation of laser cutters and 3D printers
- Application of Particle Image Velocimetry technology to characterize flow patterns

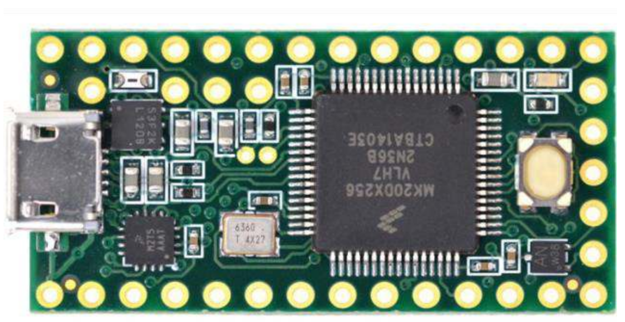


Fig. 4: Teensy

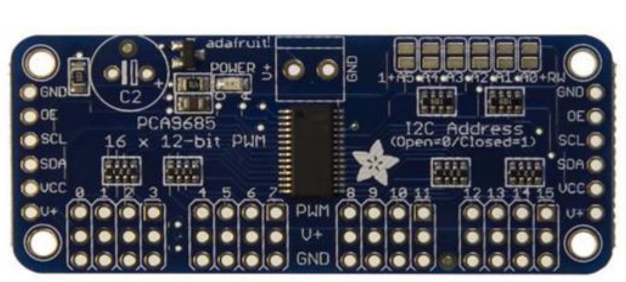
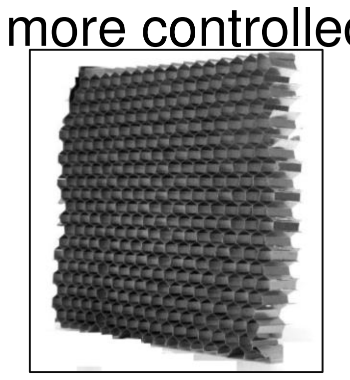


Fig. 5: Adafruit Board

Image URLs: https://www.littlebirdelectronics.com.au/teensy-3.2~42143, https://solarbotics.com/product/19000/
https://sep.yimg.com/ay/yhst-61592496875354/120mm-airflow-straightener-without-housing-5.gif

Next Steps

- Applying our research on flow straighteners (hexagonal mesh used to reduce turbulence produced by the fans; *see below*) to create more controlled air patterns
- Designing a casing to create an enclosed wind tunnel
- Using the wind tunnel to test small aircraft and other objects for aerodynamic efficiency



Flow Straightener

Advice for Future SHINE Students

- Never be afraid to ask questions and seek clarifications on new concepts.
- Invest yourself fully in your research project by studying the particulars of your project in greater depth on your own time.
- Be open to gaining exposure to a variety of engineering fields.

Acknowledgements

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