Computer Fan Wind Tunnel

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SHINE
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Introduction

Turbulent flow over complex surfaces is not well understood. Experimental data for turbulent flow over bluff-bodies simulating real life flow scenarios is limited. A large scale wind tunnel is expensive and doesn't provide us with enough control for wind speed across it. Our objective was to create a device that could better simulate real-life wind conditions, such as gusts or shear, so that a better understanding of flow over airplanes and cars in turbulent flows can be achieved.

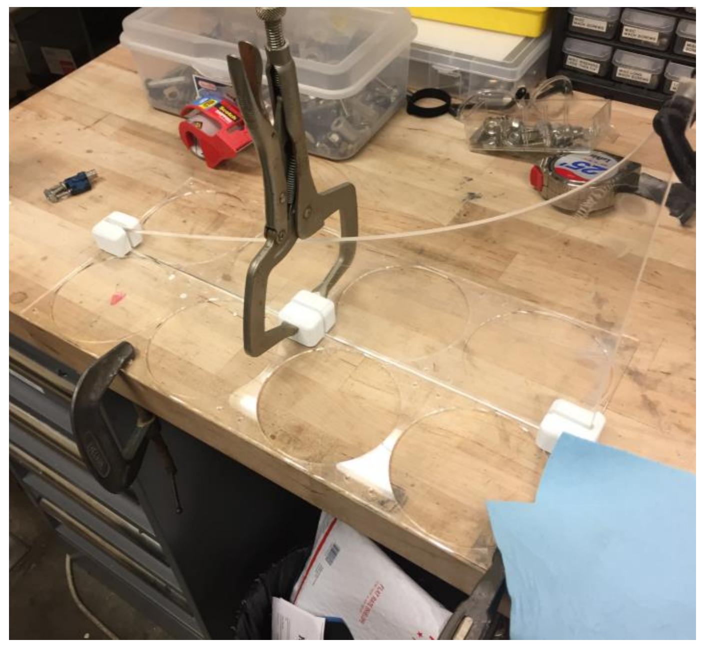
Objective & Impact of Dr. Luhar's Research

Dr. Mitul Luhar's lab is focused on understanding how turbulent fluids flow over complex surfaces. This includes porous, rough, and/or compliant surfaces— essentially, everything from golf balls to spacecraft, and shark skin to bird wings. An understanding how fluids interact and move over these types of surfaces can lead to many technological advancements, such as making faster, more efficient ships by reducing drag, or safer planes by lowering their stall speed. Our role in his research was creating a way to generate turbulent flow, in the form of an array of sixteen computer fans.

Building the Fan Array

The fan array is built out of sixteen 120mm computer fans, arranged in a 4x4 grid. The fans are controlled by a Teensy 3.2 microprocessor attached to an Adafruit 16-channel PWM driver. This allows us to control each fan individually, which allows us to create more complex wind patterns. The fans are powered by a 12V computer power supply unit.

The fans themselves are attached to laser-cut acrylic sheets, which were modeled using Solidworks. To provide vertical support and stability to the array, we also laser-cut parabolic supports. To help keep the supports vertical while they dried, we 3D printed alignment blocks.

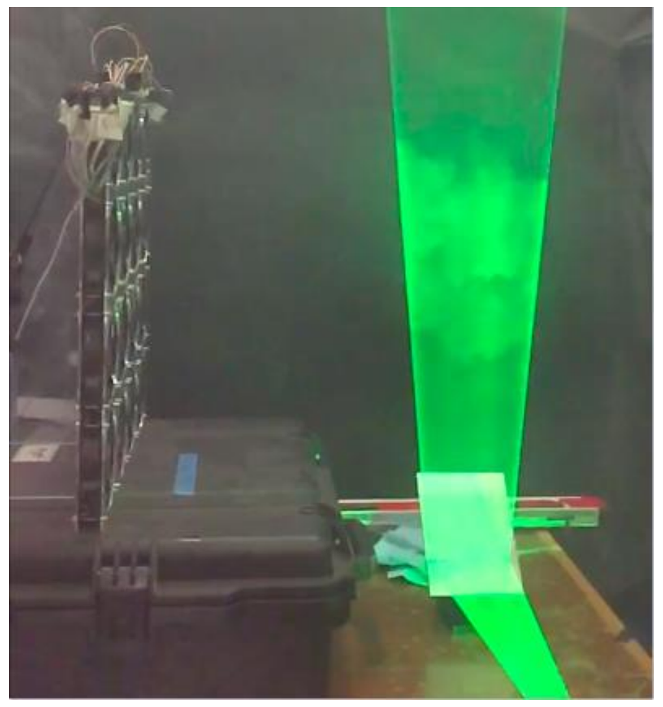


The parabolic support being glued to the acrylic sheet. The alignment blocks are the small white squares. PC: Brody Bishop

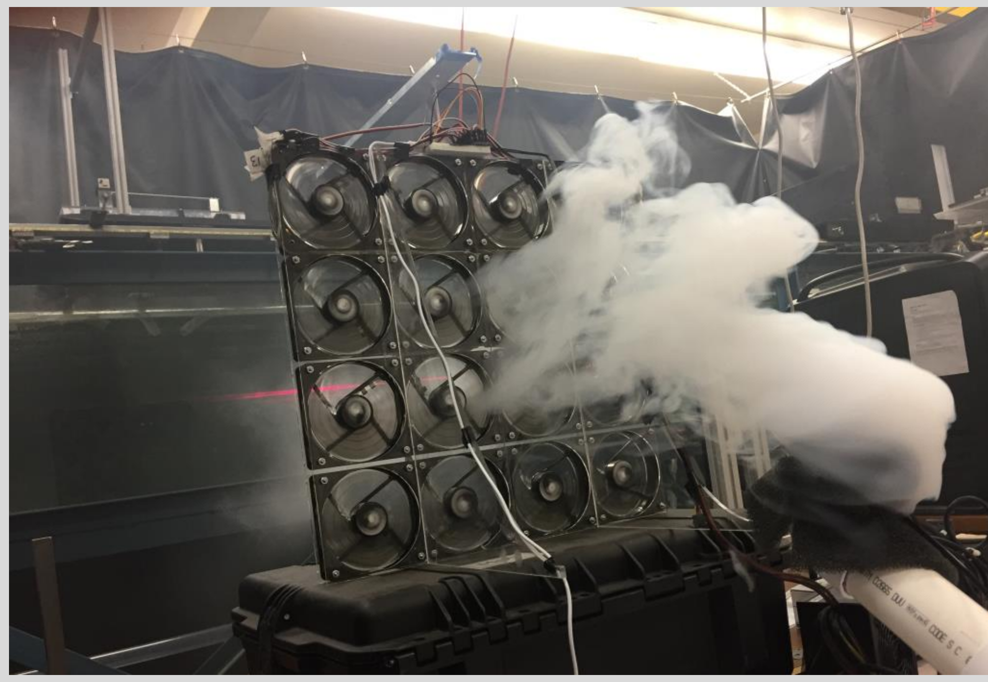
Two finished sheets next to each other, showing what the finished product will look like. PC: Brody Bishop

The (mostly) final product. This is what the array looks like with all of the fans screwed in. PC: Brody Bishop

After building the array, crimping custom PWM to servo connectors, and doing lots of internal wire management, we finally had the chance to test the array. Our original plan was to use an Laser Doppler Velocimeter—which uses the Doppler effect to measure fluid speed—to make a model of the airflow pattern around the array, but the smoke machine we used did not atomize the glycerin— the laser went right through it. Instead, we used a different method, called Particle Image Velocimetry, to visualize the flow pattern.



Using PIV to visualize a shear pattern, with the top rows of fans blowing harder than the bottom rows. PC: Sarah Fry



Testing the fan array using a smoke machine and the LDV

Potential Improvements

Ideally, given more time and more resources, there are some improvements we would have loved to make. Expanding the array to 64 fans would have made it much more valuable for testing. Using a flow straightener—most likely a honeycomb mesh— would have given us more control over what turbulence is intended and what is not. Additionally, encasing the entire panel in a tunnel, to make it a wind tunnel, would also help improve the flow.

Acknowledgements

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