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Summer 2016

Summer Report

This summer, I was at the United States Forest Service Southern Research Station in Athens, Georgia. The primary focus of their research is fire. The research group I worked with currently studies the effects of prescribed burns and tries to understand and model the science of how fire moves and spreads. Scott Goodrick, one of my supervisors, is particularly interested in studying fire from a fluid dynamics standpoint, understanding the patterns it makes and how the air flows as it burns. Recently, he has been working on a new method for measuring the velocities of smoke and flames by using Particle Imaging Velocimetry on videos taken of controlled burns. A computer program, written using *Python*, takes the video and compares each frame with the one before it to determine how far particles have moved in the time between the frames. That distance is divided by the amount of time between frames to return the instantaneous velocity of each particle. It overlays the video with a vector plot that graphs the direction of flow at evenly-spaced points and colors the arrows based on velocity. The greatest advantage to a program like this is that it minimizes the need for expensive instrumentation to be placed in the fire. With it, the only equipment needed is a camera and a computer to compile the data. One of my jobs this summer was to understand how the program worked, streamline it, and then add things to it to make the analysis more complete.

Now, at the end of the summer, the program has the capability to graph the velocity, one second moving average, and turbulence at any one point; it also does a principle component analysis on the data which finds the patterns in a large set of these vector plots (which ends up removing a lot of the useless data) and returns a vector plot with these patterns. This was the largest project I worked on over the summer. It taught me proficiency in *Python*, which is useful in many other settings and gave me a glimpse into the world of fluid dynamics. It is very likely that I will be included as an author on two academic papers written about this new method of more efficient data collection. In return, the Forest Service now has a program that they can use to understand fire dynamics better which they can use in further research without having to send expensive equipment into the fires.

I also was also involved in a few other smaller projects. The Sewanee graduate who is also interning with the Forest Service, Joel Stewart, has been working with Kevin Heirs and Nate Wilson in Sewanee's Environmental Stewardship and Sustainability department to set up a weather station on Sewanee's campus. There have been some difficulties in the setup of this weather station and I went with Joel to Sewanee to try to fix the problem. The weather station works by gathering data at a remote site and then sending the details to a computer in Breslin Tower via radio antennae. Since the biggest difficulty was getting the radios to talk to one another, we first troubleshot the antennae in the lab and were able to get them working. Unfortunately, when we brought them back to the university, they still would not talk to one another, so this is a continuing project. Hopefully, once all of the problems have been ironed out, Sewanee will have their own complete weather station which they can use to give a more complete set of information to the National Weather Service and use in studies of their own.

Over the course of the summer, my supervisor instructed me to study fluid dynamics and make my own fluid dynamics simulation on the computer. Through this, I was able to get a very basic understanding of how fluids flow around surfaces and through different structures. As a prospective pilot and plane mechanic, this knowledge is very beneficial to me. Understanding how airplanes fly is essential in repairing and piloting them. Though the internship was mostly focused around fluid dynamics as applied to fires, it renewed my interest in general and commercial aviation.

I learned a lot this summer. Three months ago, I was a complete amateur in the world of computer programming: I now am able to work with intermediate *Python* programs. In my various projects, I learned how to use *Python* for data crunching, making three dimensional models, and for creating different types of graphs. Each of the different tasks gave me experience in troubleshooting where previously, I had very little. I learned how difficult it is to make sure a computer program is doing what you want it to do and how problematic equipment can be, isolating problems is easier done in pairs because it is easy to miss the mistake when you have seen it enough to make it familiar, and there are usually more problems than initially anticipated. Though I have not yet learned enough fluid mechanics to use it by myself, my interests have been whetted and I know enough to aid me in future study on the subject.

In the future, I am not sure that I will go into fluid dynamics or computer programming, not because it was not interesting but because my current heart's desire is in aviation. Seeing the models of airflow when learning about fluid dynamics inspired me to think of how it flows around the structure of an aircraft. For example, at one point in the process of learning, I came upon an explanation of how and why a pitot tube (a device for determining airspeed and altitude) works, which is especially valuable to understand in maintaining aircraft. So, though I did not work on or with aircraft this summer, my work with fluid flow and visualizing velocities of smoke reminded me of my love for and desire to work with aviation.