

Background

In this project I aim to design and implement Tactile Feedback sleeves, controllable via computer. Of the five senses, the two most used by pilots flying an aircraft are visual and auditory. They look out of the aircraft's windows and they also listen to sounds such as the aircraft's radio. This is where the sense of touch comes in. There is typically no feedback from the aircraft that tells the conditions of the wind on each wing (e.g., as if you stuck your arm out the window). The idea is to develop arm sleeves that will give the pilot feedback through touch.

Our goal is to use vibrations to let the pilot feel the air like a bird. Bird wings have mechanoreceptors that seem to let them feel the airflow over their wings (Brown & Fedde, 1993). Vibrations may provide a suitable representation of the airflow over the wing because the vibrations will be easily sensed on the pilot's skin and hence may enable a quick reaction. Other methods to stimulate the skin are possible, and in a co-submitted UROP proposal by M. Wronski we are also planning to use tactile feedback via micro air fans. It seems very likely that we will need to explore multiple methods of tactile stimulation to find one that fulfills our requirements.

Through an array of vibration feedback, the pilot could feel a representation of the pressure from a warm air stream pushing up on the wings and be able to fly into it in order to stay in the air longer. Turbulence might also be felt before it was too late and the aircraft stalled. Additionally the pilot's flight experience could be much like that of a bird, which is what humans have been trying to achieve for millennia.

Research and Implementation

The sleeves being built in this project will be constructed using an array of vibrating motors. In this project I will be using pancake shaped pager motors similar to those used in cell phones. These motors will be placed in an array inside a pair of fabric sleeves that will be wired to a microcontroller (a single chip computer). To do this, the pager motors must be wired to Op Amps (voltage amplifiers) which are then connected to Digital-to-Analog (DAC) converters. The DACs convert the digital output from the microcontroller into an analog signal for use with

the Op Amps. The DACs also connect to the microcontroller and then to a separate computer (via a USB interface) which will provide high-level control commands.

Vibrating motors (such as pager motors) have been used to provide tactile feedback for many years and are inexpensive (e.g., Hayward & MacLean, 2007; Spirkovska, 2005). I will implement variable vibration intensity by running the pager motors through a microcontroller instead of simply turning them on and off. Variable intensity is important because the pager motors might begin to cause pain if they are left on too long in one location (Hahn, 1966; Schatzle, et al. 2006). Also, the wind pressure read from the sensors will always be changing and will need to map to varying tactile feedback. These motors must also be placed a certain distance apart in order for the user to be able to recognize distinct sources of vibration (van Erp, 2005). Determination of an appropriate placement distance can be done by turning on the pager motors and seeing at which point a person can distinguish between one and two vibrations.

Evaluation and Report

The main way of evaluating this project will be to assess if the person wearing the sleeves can distinguish between the multiple patterns of vibration. In other words, the system will be tested by feeding it pairs of vibration patterns and asking the subject wearing the vibrotactile sleeves whether or not he or she can feel the difference between the patterns. Once the testing is finished the results will be described and analyzed in a report.

Project Budget and Schedule

The project will have a 12-week agenda, for which I request the full \$1,400 compensation. This amount funds up to about 10 work hours per week, totaling 121.74 hours at a rate of \$11.50 an hour. The 12-week time frame will provide sufficient time to design a circuit with motor array and microcontroller, test the circuit, interface the circuit with a separate computer, evaluate its performance, and create a report of the results. The future aspirations of this project will be to use pressure sensors and place them on a glider wing and then implement

Tactile Feedback for a Sailplane Pilot Giving Wing Air Conditions: Vibration Motor Sleeves

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the circuitry into a glider. To cover materials expenses (microcontroller, DAC's, Op Amps, and pager motors, and fabric for sleeves), we request \$200.

Time Line

Design vibrotactile sleeves:	3 weeks
Implement circuitry:	3 weeks
Write computer interface:	4 weeks
Summary and report:	2 weeks
Total:	12 weeks

Faculty Mentor's Role

Dr. Prince is already actively involved in the fluid dynamics of a plane's wing, along with his advisee Prasad Kulkarni. Prasad is simulating the airflow over a wing using fluid dynamics simulation software with the aim of creating simulated sensors on a simulated glider wing. These simulated sensors will eventually be used to provide test input data for our tactile feedback sleeves. Dr. Prince has been working with collaborators in UMD mechanical engineering and electrical and computer engineering to expand his knowledge to cover the concepts of fluid mechanics and electrical engineering needed for this project. He owns a sailplane and his interests are directly related to my proposal. He will oversee my research project and provide any help if I am in need of assistance. He will also contribute time and effort to the USB computer interface.

Research Motivation

This project appeals to me for several reasons. There has been little done in computers as far as tactile feedback is concerned. Emulating the feeling of touch through the digital threshold is something that will be used more in the future. I am a student at the University of Minnesota Duluth studying in Computer Science and Electrical Engineering. By taking on this project I will learn much information in circuitry design and motor control that is integrated with computer software.

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