Tactile Feedback for a Sailplane Pilot Giving Wing Air Conditions: Micro Fan Sleeves

Student: Matthew L. Wronski; **Faculty Sponsor**: Christopher G. Prince

Background

The goal of this project is to construct tactile sleeves for a sailplane pilot that relay the exterior wind forces on the sailplane to the pilot in the least obtrusive way possible. The plan is to give the pilot the sensation of variations in air pressure on parts of the wings through directed air streams that would blow on the pilot's arms from elbow to shoulder. Research is presently being carried out by Prasad Kulkarni and Christopher Prince on the perceptual usefulness of air flow and pressure data on a wing for a pilot. This research may give the pilot an enhanced sense of the aircraft's position in relation to the surrounding air currents, and it could also aid the pilot in performing safer maneuvers, better enable locating and exploiting air currents for lift, and improve the enjoyment of flying.

Previous research has provided airflow feedback in simulated flying situations (Cardin et al., 2007; Soares, et al., 2005). Some tactile feedback research has used air jets in other types of virtual reality applications (Kim et al., 2006; Suzuki & Kobayashi, 2005). Some research has provided visual pilot feedback regarding the temperature of the air from sparse locations on a sailplane wing (Behan et al., 2008). However, to our knowledge, no previous research has used an array of small-sized air streams to provide tactile feedback in an aviation application, and furthermore, to our knowledge no earlier research has given the pilot high-resolution tactile feedback of airflow conditions on the wings of an aircraft.

We propose to use an array of micro air fans to provide tactile feedback to a pilot regarding the air pressure on the glider's wings. In a co-submitted proposal, J. Parrott is using pager motors in the same context. As we don't know the kind of actuator that will be most effective, we are proposing to evaluate them concurrently. Comparing the results from these two projects (pager motors vs. micro air fans used in tactile feedback sleeves) will aid in finding the best choice for tactile use in glider aircraft.

Research and Implementation

Using air blowing across the pilot's skin seems to be a natural feedback method because we are trying to represent air pressure on the wings. Micro fans vary speed with voltage, some of these fans have built in speed sensors which could accurately be used to regulate the air flow rate, and micro fans come in sizes as small as half an inch square which could be mounted in almost any location that air tactile sensation is desired. An array of 16 micro fans mounted on a pair of sleeves (8 per sleeve) worn by a pilot could make for an accurate representation of the air forces on a glider's wings at a reasonable price, and possibly increase the safety and enjoyment of flying these non-motorized aircraft.

The fans must be controlled to the proper fan speed based on input from the air pressure sensors on the outside of the wing. The most efficient way method to achieve this goal will be to use a one chip microcomputer (a microcontroller) to output 16 voltages or one for each proposed fan. The 16 voltages can be produced using two 8-Channel DAC's (Digital to Analog Converter). The DAC will set each channel to a voltage that drives the fan at the desired speed, and that speed can be updated multiple times per second. The voltage given will need to be amplified by an Op Amp for each fan. The power needed to drive the sixteen fans (possibly) at full speed is about two amps at twelve volts which would be equivalent to a cigarette lighter in your car being run at only 10% capacity. The circuitry (e.g., the microcontroller) to run the fans will require a significantly smaller amount of current— about equal to one micro fan. High-level programming of the fans will be done through a USB interface on the microcontroller connected to secondary computer (running Microsoft Windows).

The fans will be mounted to the sleeves of a long sleeve shirt by sewing a patch of foam the size of a fan with a hole through the center to the skin and a pie wedges cut out of the sides for air flow. The wires running to the fans can then be velcroed on the sleeves and run to the microcontroller and other small circuitry.

Evaluation

As an initial test of the effectiveness of these sleeves, comprising an array of 16 fans (8 per sleeve) used for tactile feedback, we need to test: 1) whether a person can sense the difference between different levels of fan speeds, 2) whether a person can distinguish between the various streams of air provided by the various fans in the array, and also 3) whether different patterns of fans activation can be distinguished. To accomplish these tests, we will first activate each separate fan at several different speeds, and determine if test subjects can discriminate the difference between the speeds. We will next activate either (a) pairs of fans or (b) a similarly located single fan and see if the subjects can discriminate between one and two activated fans. We will finally activate sets of fans in different patterns and determine if the subject can distinguish between the two patterns. These results will tell us what fan spacing is needed, what fan speed differences are needed for supplying the greatest amount of data feedback to the pilot, and whether patterns of activation can be distinguished. In later phases of this project, testing of these tactile sleeves will be aided by fluid dynamic models (Kulkarni & Prince, in progress).

Price List

1)	Microcontroller	$10.00	sh: $5.00	$15.00
2)	8 Channel DAC (futurelec.com)	2 X $4.80	sh: $4.00	$13.60
3)	Op Amp (fairchildsemi.com)	16 X $0.62	sh: $12.35	$21.15
4)	Micro PC Fans	16 X $10	sh: $10.00	$170.00
5)	T-shirt	1 X $10		$10.00
6)	Foam sheet	$20.00		$20.00
			Total:	$235.75

REFERENCES

Behan, R., Harwood, T., & Brown, R. (2008). Glider thermal direction indicator. URL: http://engenius.sece.rmit.edu.au/Abstracts/Page601.htm

Cardin, S., Vexo, F., & Thalmann, D. (2007). Head mounted wind. Proceedings of the 20th Annual Conference on Computer Animation and Social Agents (CASA2007), pp. 101-108.

Kim, Y, Oakley, I., & Ryu, J. (2006). Combining point force haptic and pneumatic tactile displays. Proceedings of EuroHaptics. Paris, France.

Soares, L., Nomura, L., Cabral, M., Dulley, L., Guimarães, M., Lopes, R., & Zuffo, M. (2005). Virtual Hang-gliding over Rio de Janeiro. International Conference on Computer Graphics and Interactive Techniques. Los Angeles, CA.

Suzuki, Y. & Kobayashi, M. (2005). Air jet driven force feedback in virtual reality. IEEE Computer Graphics and Applications, Jan/Feb, 44-47.