Cockpit Display using Tactile Sensation

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Abstract

A new cockpit display system using tactile information was proposed. A 6x4 pin-array-type tactile display device was mounted on an aircraft control stick, and provides a pilot with altitude tracking cue. Results of preliminary pilot-in-the-loop simulation demonstrated that this system could support a pilot in maintaining an assigned altitude with only partial reference to altitude and/or vertical speed instrument indications.

1. Introduction

Pilots must monitor flight instruments inside the aircraft while at the same time carefully watching outside when they are flying an airplane or a helicopter. Looking outside, pilots scan for other aircraft, watch for obstacles, and possibly navigate. At the same time, the pilots grasp the flight state by monitoring flight instruments such as the altimeter, vertical speed indicator, attitude indicator and airspeed indicator, and navigate using navigation instruments. Internal and external visual information are equally necessary for safety of flight, but pilots' visual information channel is almost saturated. Therefore, some problems such as disorder of an aircraft, some obstacles in the area or bad weather may easily prevent them from adequately attend to visual information acquisition, particularly in single-pilot operations. In this report, we describe a new pilot supporting system aimed particularly at small airplanes and helicopters that uses tactile sensations to convey primary flight information to the pilot. This system should enable pilots to control an aircraft based on sensations from a tactile display without increasing visual workload.

2. Previous research

The visual senses have been used as means of displaying primary flight information such as altitude, attitude, vertical speed, airspeed, heading, and engine power. However, recently the tactile sense has started to be considered as an effective channel for displaying flight information [1], and research has been carried out on tactile displays [2][3]. However, those researches mainly focus on tactile sensation of torso. In those researches, pilots wear a vest or a flight suit with vibrators, which convey flight information through tactile sensation. However, to convey tactile sensation positively, such clothes often become tighter than conventional clothes. Many civil pilots (especially private pilots) should stay away from wearing such clothes for all the time during the flight On the contrary, when tactile sensations are displayed to the fingertips, those problems related to clothes are solved. Fingertips have reduced area for displaying tactile sensation but the resolution of touch sensitivity is high. Such higher resolution should allow us to display many kinds of information. In the next section, we describe about display method.

3. Display method

In this study, we display path angle error information through the tactile display to keep appropriate vertical trajectory. The path angle error is defined as the error angle between current flight path and interception path to the target trajectory (Figure 1).

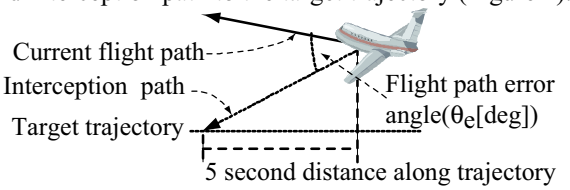

Figure 1. Error between current and ideal path

If there is an error between those two paths, a tactile signal is generated. For displaying such information, we use three KGS Inc. SC-9 pin-array-type tactile display units. The configuration of the display is shown in left side of Figure 2. The pin stroke length is 0.7 mm and the pins are popped up with a force of about 18 gf. Right side of Figure 2 shows example pin pattern to display flight information. In this figure, pin

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pattern cycles through patterns (A) to (F) to indicate pitch down command through apparent motion of pins

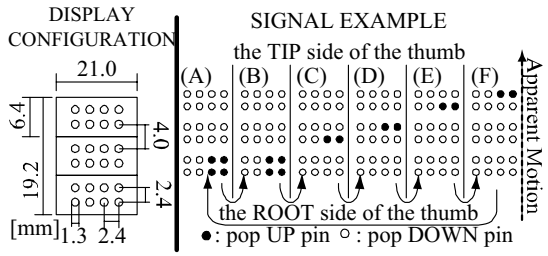

Figure 2. Display configuration and signal

Our system supports three speeds of apparent motion to indicate the magnitude of flight path angle error. The speed of apparent motion is changed by changing the displaying time for each patterns shown in Figure 2 from 80[ms] to 150[ms]. Between each patterns, all pins pop down for 50–150[ms]. In the next section, we describe about our experimental system and result for a preliminary experiment.

4. Experiment

As the preliminary phase of the research, a series of flight simulation experiment was conducted to investigate the effectiveness of the proposed display device by comparing some combinations of tactile and visual information.

This experimental system was composed of a flight simulator running on a laptop computer, IBM ThinkPad X31 (CPU: 1.4 GHz, OS: RedHat8.0), a joystick as a control device, and the tactile flight information display described in section 3, which was mounted on the joystick(Figure 3). The modeled aircraft of the flight simulator was Dornier 228-202. For ease of evaluation, only the elevator was manually controlled. The ailerons, rudder, and engine power of the aircraft were automatically controlled to maintain lateral course and airspeed. The wind was a direct headwind at 5 m/s, with has a σ=0.8 m/s random gust component.

Figure 3. Experimental system

Subjects were required to track an 8 km-long straight level flight path at assigned altitude.

Four display configurations of NORMAL, NO ALT, NO VS and TACTILE were compared. For the NORMAL case, the pilot could use visual altitude meter and vertical speed meter. For the NO ALT and NO VS cases, the tactile display was used with either vertical speed indicator or the altimeter alone. For the TACTILE case, only the tactile display was used. Then RMS values of altitude error and standard deviations of it were compared between cases. The experiment was conducted using four well-experienced pilots, subjects A, B, C and D, The result is shown in Figure 4.

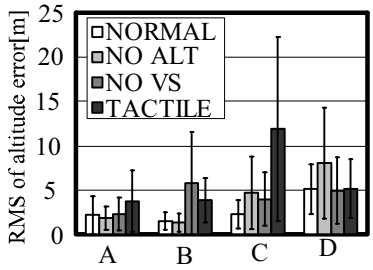

Figure 4. Experimental results

From the result, except for subject C in the TACTILE case, no subject exceeded 15 m altitude deviation for any cases. The tactile display could successfully compensate the lack of visual display information, and the tracking error of NO ALT, NO VS and TACTILE cases were suppressed as the same level as those of NORMAL cases

5. Conclusion

In this report, we have proposed a supporting system for pilots using a tactile display and conduct a preliminary evaluation. The evaluation demonstrated that this system could support a pilot in maintaining an assigned altitude with only partial reference to altitude and/or vertical speed instrument indications.

For the future, more examination should be needed especially under visually heavy workload configuration. Then, we continue researching on appropriate information and signal patterns.

6. References

[1] Henricus A.H.C. van Veen et al., "Tactile Information Presentation in the Cockpit", Proceedings of the First International Workshop on Haptic Human-Computer Interaction, p.174-181, August 31-September 01, 2000.

[2] Jan B.F. van Erp et al., "A Tactile Cockpit Instrument to Support Altitude Control", Proceedings of the Human Factors and Ergonomics Society, 47th Annual Meeting, pp.114-118, 2003.

[3] Anil K. Raj, et al., "Vibrotactile Displays for Improving Spatial Awareness", Proceedings of the IEA 2000/HFES 2000 Congress, vol.1, pp.181-184, 2000