DESIGN OF AN EFFECTIVE HAPTIC FEEDBACK DEVICE TO LIMIT AVIATION TASK SATURATION (H-FLATS)

A Proposal
Presented to
The Academic Faculty

By

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LIST OF ACRONYMS

FBW fly-by-wire

UAV unmanned aerial vehicle

SUMMARY

Capable piloting of an aircraft, both traditionally and remotely, requires access to and careful monitoring of a plethora of instrument readings. This non-trivial task is but one of many items a pilot must tend to during flight. Utilizing unconventional mediums for communicating some of this sensory information presents an opportunity to decrease task saturation for the pilot. One such medium with room for expansion is haptic feedback.

Haptic feedback has existed in the cockpit for decades, but not outside forces on the stick or yoke. It is possible that the same force feedback properties applied to control surfaces could be conveyed via devices not connected to the aircraft.

This work seeks to explore the effects of haptic feedback devices affixed directly to the pilot and their effectiveness in flight.

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Motivation

Task saturation is defined as is defined as the perception or the reality of having too much to do and not having enough time, tools or resources to get them accomplished. This is most commonly attributed to the world of aviation where pilots must monitor their instruments, monitor the airspace, provide control inputs, make and receive radio calls, navigate a flight plan, etc. The list grows evermore expansive in the context of military aviation where weaponry, targeting, evasion, and so much more are added as essential considerations. The ability of a pilot to conduct a mission is much broader than the baseline task of aviating and is impossible with their eyes glued to their instruments.

This work seeks to lessen the problems of task saturation by augmenting pilots with devices capable of relaying sensory information without the need to focus in on an instrument dial.

1.2 Prior Work

Haptic feedback has always naturally occurred in aircraft through the form of external forces on the control surfaces and buffeting of the aircraft. However, the first man-made integration of haptic feedback in the cockpit dates back as early as 1949 with research on stick shakers[1]. Stick shakers are devices that cause a control stick or yoke to vibrate as a means of warning a pilot of a stall. The technology would become crucial to the development of fly-by-wire (FBW) aircraft where the flight controls are electronically, not mechanically, tied to the control surfaces, which thus do not provide natural force feedback[2]. The use of artificial force feedback simulates the resistance to inputs naturally given by control surfaces, which greatly improves the flying qualities of the aircraft.

Since, studies have been conducted with other artificial control stick forces and brought to the realm of robotics with drones. One such study attempted to convey flight performance measures as different vibrations on the control stick, which resulted in high satisfaction from tested pilots[3]. Another study examined the effects of flying in visually limited settings, such as a unmanned aerial vehicle (UAV) with a single camera, in precision environments; the work demonstrated that haptic feedback on the control stick, which indicated the proximity and direction of an obstacle, improved the rate of success and safety of flight patterns[4].

CHAPTER 2
POTENTIAL CONTRIBUTION

2.1 Overview

While much has been done to leverage the capabilities of haptic feedback on the flight controls, little has been done to exploit the rest of the human body and its capability for haptic feedback. Devices capable of providing information by touch to the skin already exist and can be integrated into this field. The purpose of this work is to connect haptic feedback for piloting to non-flight control mediums to more reliably pilot a UAV.

2.2 Incremental Development Strategy

This project will aim to utilize increasingly complex and haptic feedback devices. As a first step, a sphygmomanometer, which is typically used to measures blood pressure, will be used to provide information about vertical speed. Additional feedback devices will be brought in to increase effectiveness and explore wider ranges of possibilities. There is also potential to use haptic feedback with the goal of controlling multiple UAVs simultaneously.

CHAPTER 3
EXPECTED METHODS

3.1 Materials

Flight will be conducted using the CrazyFlie 2.0: a relatively cheap, small, and capable UAV. Through the Robotarium, I will have access to 8 units for both redundancy and potential swarming purposes.

Through the Robotarium, I will also have a safe, controlled environment to fly, test, and measure the performance of the drones. The environment possesses MoCap capabilities for testing and localization purposes.

Haptic feedback devices will be procured and developed with the support of the Robotarium as well.

3.2 Flight Test

Early stages will likely rely on standard flight with augmentation of haptic feedback devices for training. Then the addition of disturbances, either artificial or real, will enable testing of the pilot's ability to return to stable flight. Later stages could remove traditional cues such as sight or hearing with the goal of evaluating the haptic feedback devices alone.

3.3 Simulation

The use of simulation environments would be a worthwhile addition to the project due to its availability and modularity.

CHAPTER 4

SCHEDULE FOR SPRING 2023

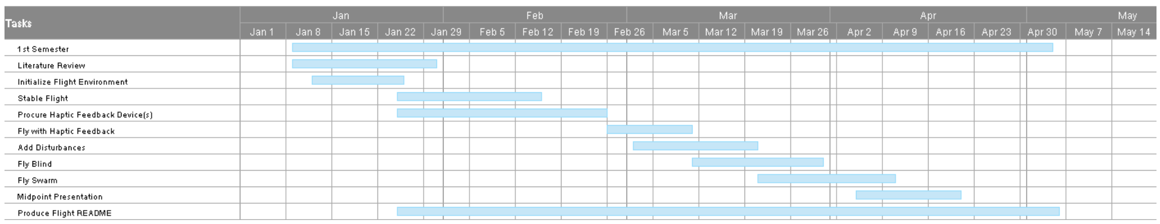

Figure 4.1: First Semester Schedule

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