Wireless Gesture-based Controller for Drones

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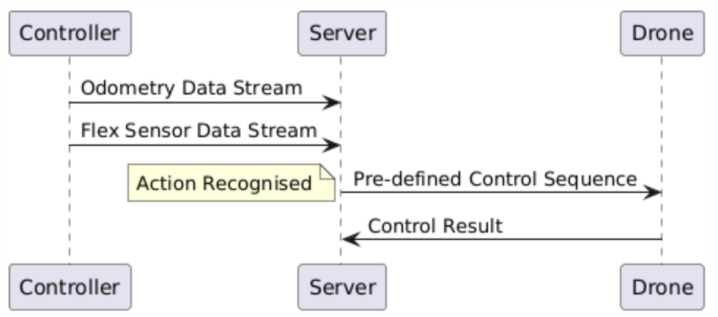
1 Proposal

1.1 Introduction

1.1.1 Project Aim

This project will aim to create a system in which a gesture-based controller can be used to operate a drone. The controller will rest on the back of the hand (most likely a glove), and passively detect any pre-defined motions made by the user. For example, if the hand draws a square in the air, this is interpreted as some kind of command and an action is triggered. The data collected by the glove would most likely include odometry (acceleration, attitude) and flex sensor resistances for each finger. The controller will send data to a control server (hosted on a laptop), which will then interface with the DJI Tello drone using a provided SDK.



1.1.2 Motivation

This project idea is an extension of a small side-project I had in first year - I wanted to be able to control a drone using hand gestures. Though short-lived, I managed to achieve a basic system where an MPU6050 could be used to control the pitch, roll and yaw of a DJI Tello drone.

I would now like to take everything I've learnt over the last 3/4 years (and more) and convert this half-baked idea into a viable product. I believe it is broad enough to allow me to work on many levels of the tech stack - hardware and signal processing all the way up to the software on the control server.

Figure 1.1: DJI Tello Drone

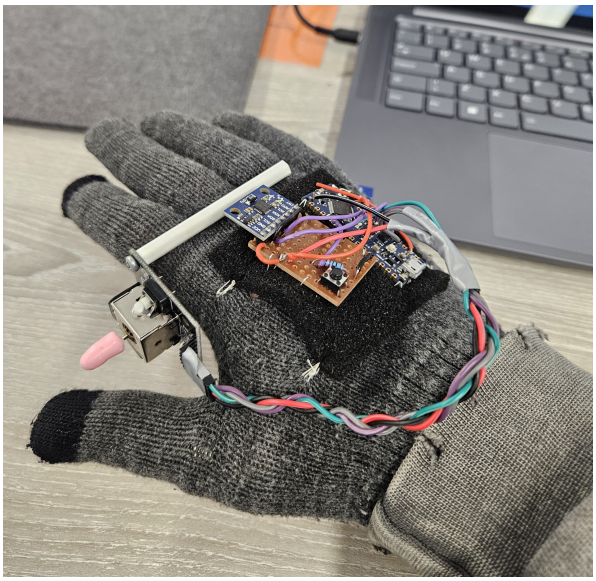


Figure 1.2: Early 2021 Controller Prototype

1.1.3 The DJI Tello Drone

The drone described in this project is one that I have used before - it is a simple quad-copter designed by DJI that can be easily controlled over sockets using the provided SDK. I will not focus on the actual control of the drone since this is a solved problem. There are obviously possible restrictions that come with using a drone, these are addressed below in the **restrictions** section.

1.2 Technical Skills Overview

1.2.1 Prototyping

The controller created should not look like the one in the early 2021 prototype - I would like to create a sleek design that looks like an actual product. I will investigate the feasibility of using a flexible PCB, as suggested by Ed Stott. All the electronics should be reasonably protected and not exposed.

1.2.2 Embedded Software

The project will require some embedded software skills, in order to read data from the sensors connected on GPIO pins, process it and send it to the control server. This will likely involve working with an RTOS.

1.2.3 Signal Processing

The odometry and flex-sensor data will require signal processing for optimal results. Some of this might be done on the glove itself using software, but the large majority is likely to be done on the control server using Python or otherwise.

1.2.4 Machine Learning

Detecting actions will require some serious data processing using machine learning. It is likely that a Markov-chain approach will be taken, but this is up for debate pending the initial background reading.

1.2.5 High-level Software

The control server will need to communicate with both the drone and the controller at the same time. It will also need to be running the gesture-detection algorithm. These functions will probably be written in Python. For best results, it is likely that they will be split into different micro-services (using docker or otherwise).

2 Project Considerations

2.1 Risk Assessment

The signal processing and machine learning components have the ability to make-or-break this project. Without good data, it will be impossible to train a model, and without a good model the system will not be able to make accurate decisions. I believe these are the critical sections that will require the most background reading and planning.

In addition, if a PCB is to be considered, this will need to be sorted as soon as possible to avoid long wait times from manufacturers.

2.2 Restrictions

2.2.1 Battery Powering the Controller

If the controller is going to be mounted to the user's hand, it is important for the power source to be lightweight and compact. The obvious choice would be a LiPo battery, but given the EE safety regulations I believe it would be better to just run a small microUSB cable to the glove and keep it tethered, or connected to a powerbank that the user keeps in their pocket.

2.2.2 Drone Simulation

Flying the drone in EE labs (or pretty much anywhere on campus) is most likely out of the question, therefore it might be suitable to create a drone simulation to test with. Ed Stott has suggested that Unity might be a suitable tool to use here.

However, as mentioned in the section **The DJI Tello Drone**, controlling the drone itself is a solved problem that will require minimal effort, particularly since I have used the SDK before. A large part of the testing can therefore be done agnostic of the drone, and by simply observing if the model outputs the correct actions based on certain test data.

2.3 Possible Extensions

In the interest of scoping the project well, I have kept the proposal MVP to just a glove that can control a single drone. However, should sufficient progress be made, below are a couple avenues that could be explored.

2.3.1 Swarm / Multi-Agent Technology

Can multiple drones be connected to the same control server, and all controlled using the same glove? What kind of tasks could they perform as a swarm?

2.3.2 Image Processing

The DJI Tello has a basic camera mounted to it. It's not particularly high resolution, but could be used to perform some basic image processing tasks such as object recognition / colour processing. This would open the floor to new commands, such as 'find the blue ball'.

A scenario where both or even one of these extensions is explored is optimistic, but I thought I would mention them nonetheless.