ECE 445

Project Proposal

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VR Motion Control for Drones

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1. Introduction

1.1 Objective

Drones are becoming more and more available to hobbyists, but the controls are a hurdle both to amateurs looking to use their first drone and to more experienced users desiring more precise movements. Almost all drone systems use an RC controller with joysticks to control the thrust of the motors on the drone, which is unintuitive and imprecise. We would like to create a method of controlling a drone with a user's body and head movement so that it becomes easier for the consumer to control their drone.

1.2 Background

Quadcopter style Unmanned Aerial Units (UAVs) often dubbed as drones are ubiquitous today. With cheaper parts via 3D printing and with various kits to design these drones we have them flourish hobbyist markets and for business purposes.

A huge issue with drones is still the lack of intuitive controls. Most commercial drones used for research in geospatial technologies and GIS surveys require a pilot's license due to the complexity of controls.

While interning at Bayer during the summer of 2019 in their UAV Analytics team I saw the amount of training and work a Drone operator has to go through. We wanted to make this process easier and give users a more intuitive way to control and interact with drones.

We want to use the motion of the Body of the User to extrapolate where they are looking and adapt the VR headset and the drone to mimic that motion allowing for a seamless and intuitive control system.

In Spring 2019, Group 22 created an intuitive drone controller that utilized a glove with gyroscopes and accelerometers to control the motion of a drone. Our project is fundamentally different in that we are incorporating a VR headset to give the user visual feedback from the drone's perspective in addition to using gyroscopes and accelerometers to control the drone's motion. The drone will also be a model with a movable camera, which we will be controlling again with the movement of the user's head.

1.3 High-Level Requirements

- The device must be able to sense the orientation of a user's head with an error margin of 5 degrees on each axis, and sense acceleration of a user's head in the horizontal plane.

- The device must be able to transmit orientation and acceleration data to the drone wirelessly in real time (less than 20ms for our purposes).

- The device must be able to control the camera angle and horizontal movement of the drone-based on data from the headset while movement mode is enabled.

2. Design

2.1 Physical Design and Block Diagram

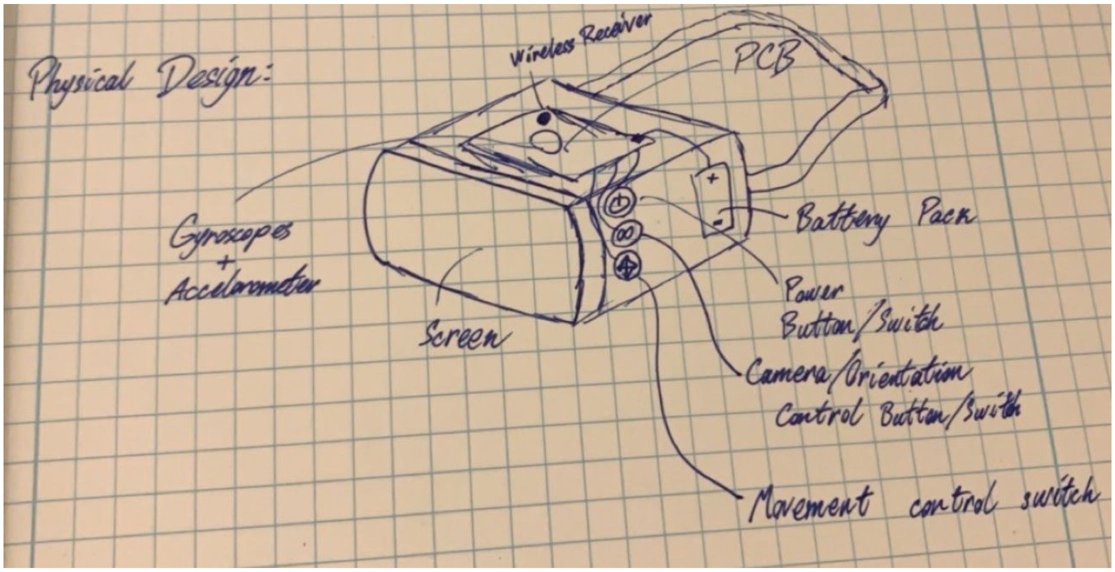

Figure 1. Physical Design of Device

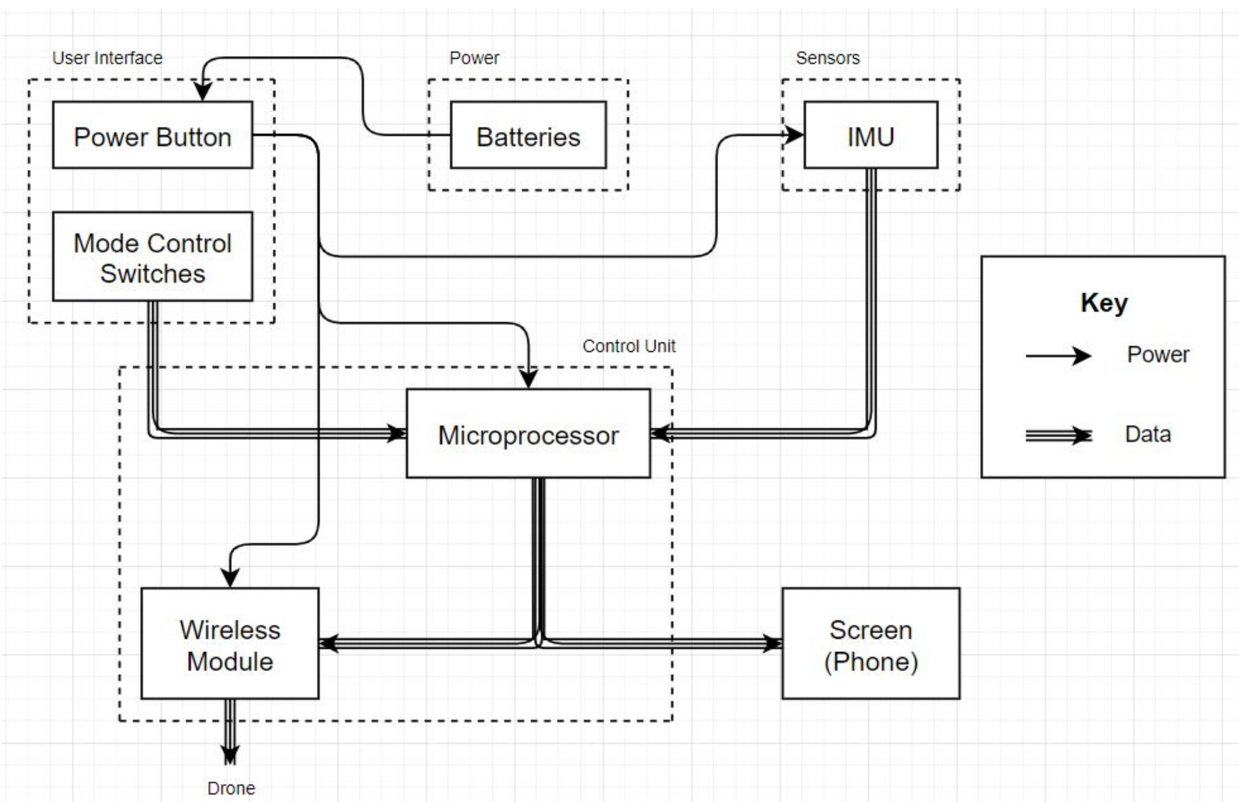

Figure 2. Block Diagram

2.2 Functional Overview

Our design needs to allow for the following in order for this project to be successful:

- Easy and interactive user interface
  - We want to create a system that will make the technology in our design invisible to the user and create a more immersive experience. The user should be able to put on our device and with the click of a button change their perspective to that of the drone.
- Active real-time operation
  - To achieve real-time operation we need to take in the inputs from the IMU [1] and perform several filtering operations with minimal delay.
- Seamless wireless communication
  - The drone must receive all inputs from the user without interruption to ensure smooth and consistent operation.

2.3 Block Requirements

2.3.1 Control System

The Control System comprises the Microprocessor and the wireless transmitter and receiver paired with the drone. The receiver broadcasts video from the drone and is redirected to the screen of the VR goggles. The MCU takes inputs from the sensors and processes them into directions for the drone and sends them to the transmitter, which then broadcasts them to the drone.

Requirement: The control system must be able to convert sensor data of which direction the user is facing and the user's horizontal acceleration and convert this into instructions for the drone. The wireless transmitter must be able to communicate wirelessly with the drone to receive video and send motion instructions.

2.3.2 Sensors

The Sensor subsystem includes the accelerometers and gyroscopes that measure the direction and magnitude of the movements of the user's head. The sensors are connected to the MCU and are powered by a small onboard battery.

Requirement: The sensors must be able to detect the facing of the headset with 5 degrees of error in each direction.

2.3.3 User Interface

The UI subsystem consists of three switches that fulfill the functions of powering on the device, enabling “Movement” mode, and enabling “Orientation” mode. Movement mode will have the drone move horizontally following the user’s acceleration. The orientation mode will have the drone rotate and change the camera angle to mimic the user’s facing.
Requirement: Switches must be able to turn on and off functions of the control system based on the mode of operation.

2.3.4 Power

The drone will be powered by its own battery unit, which we will not be modifying in any way [2].

We will be using a 5 V battery to provide power to our PCB including the IMU.

The VR headset does not require power as it uses a phone as a monitor and relies on the phone powering itself.
Requirement: The power units for the drone and VR headset respectively are already integrated into the products. Our power system must provide 5V to our PCB and IMU.

2.3.5 VR Headset

The VR headset used for this project is the default headset that comes with the drone [2]. It works using a phone as a monitor and projecting video to it through the audio jack and power port.
Requirement: The headset must be able to take video input from the control system and display it on the phone.

2.4 Risk Analysis

For this project to be successful, it is critical that we are able to process the physical data received from the IMU (inertial measurement unit). One of the biggest challenges here is the need to control the drift in the velocity values as we integrate over the momentum that is registered by the IMU. We are planning to utilize the auto pitch and drift correction module integrated in the Texas Instruments IMU that uses Direction Cosine Matrix (DCM) after calibration to allow for accurate and consistently correct measurements on the fly without needing any external monitoring algorithm or constant calibration.

3. Ethics and Safety

Our device will use voltages and currents that are small enough to not cause harm to humans, and we will have all of our wiring and hardware enclosed in plastic housing to ensure the safety of both humans and our circuitry.

We will adhere to all of the state and federal laws that are applicable to small UAV in the state of Illinois [3]. This mostly restricts any form of flight in restricted zones and flying in proximity of state-owned infrastructures like transmission lines, public offices or airports etc.

One more concern is that the drone might collide with a person or someone's personal property. We need to ensure that we follow the IEEE code of ethics concerning avoiding damage to people and property [4]. To this end, we will ensure that we have a clear area when testing our drone so that we mitigate the risk of any personal or property damage.

4. References

[1] “Nine-Axis Sensor Fusion Using Direction Cosine Matrix Algorithm on MSP430F5xx”. TI. http://www.ti.com/lit/an/slaa518a/slaa518a.pdf (accessed April 1, 2020).

[2] “Mavic 2 Specifications”. DJI. https://www.dji.com/mavic-2/info#specs (accessed April 2, 2020.)

[3] “Illinois Drone Laws”. StateDroneLaw. https://statedronelaw.com/state/illinois/ (accessed April 3, 2020).

[4] “IEEE Code of Ethics”. IEEE. https://www.ieee.org/about/corporate/governance/p7-8.html (accessed April 3, 2020).