ECE 3140 Final Project Proposal

Quadcopter Flight Controller

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1 Overview

For our final project, we would like to build a drone, using the FRDM board as our flight computer. The microcontroller board will read PWM input values from a standard 2.4GHz RC receiver. It will determine their pulse width and propagate those values through a PD rate-controller and output values to the electronic speed controllers (ESCs). These ESCs provide a three-phase output to the brushless outrunner motors. Angular rate determination is done with use of an I2C gyroscope (MPU9250). A simple form of gain scheduling will be used to combine the user's input and the angular stabilization output. Stabilization is given a constant setpoint of $\dot{\eta} = \begin{bmatrix}\dot{\phi} & \dot{\theta} & \dot{\psi}\end{bmatrix}^T = \begin{bmatrix}0 & 0 & 0\end{bmatrix}^T$. Note that this control system is not full roto-translationally reachable, and will be built to simply minimize angular error. If we can achieve flight with this controller, and have time, then we would like to implement an altitude control system with the VL53L0X I2C time of flight lidar sensor.

We both have experience with building quadcopters from scratch and believe this project to be feasible. Beyond this, Eric has noteable robotics experience, and Padraig has notable control system design experience.

2 System Description

The full system is built on top of a fiberglass QAV250 'H' quadrotor chassis. It will have four 2300KV brushless outrunner motors, two pairs of clockwise and counterclockwise rotation. Each will have a propeller and will be controlled by an ESC module. This module takes a PWM input and outputs a three-phase current for the motor. The FRDM NXP board will act as a flight computer and will output PWM for each of these ESC modules. This board will need to read angular rates from an IMU, which will be placed at the center of the body frame. This MPU9250 sensor is a MEMs I2C device. The flight computer will have to set up communication with this device, and pull data from the proper registers. The flight computer will also need to read four incoming PWM signals from the on-board 2.4GHz remote control receiver. Power is distributed to each of these devices by means of a power distribution board at the center of the chassis. Power is sourced from a 3S lithium-polymer battery back.

3 Technical Tasks and Testing

- Build the chassis and power distribution system [Completed]
- Test each ESC and motor with receiver to confirm full functionality [Completed]
- Start writing controller code [Started]
- Write function for outputting PWM signals
- Test function on each of the motors
- Write function for reading PWM using timers from RC receiver
- Test function with flight hardware to determine functionality
- Test receiver –> FRDM –> motors, to make sure of preservation of signal with negligible latency
- Write code to pull values from IMU
- Test code, display the roll/pitch/yaw values to confirm functionality

- Finish controller code by stitching other functions together
- Test full-loop controller code
- Tune controller gains and continue testing
- If time allows, write I2C code for VL53L0X sensor, test and integrate into controller code

4 Development Timeline and Milestones

$$\begin{bmatrix} \text{April 23rd – April 29th} \\ \text{April 30th – May 6th} \\ \text{May 7th – May 13th} \\ \text{May 14th – May 20th} \end{bmatrix} = \begin{bmatrix} \text{Write all PWM code, test, confirm functionality with receiver} \\ \text{Write IMU code, integrate and test, confirm motor functionality} \\ \text{Finish controller code, integrate and test, confirm motor functionality} \\ \text{Tune controller (add altitude control if time), turn in report and demo!} \end{bmatrix} \tag{1}$$

5 Work Distribution Plan

- Hardware Assembly [Padraig]
- Implement PWM reading functionality [Eric and Padraig]
- Implement PWM writing functionality [Eric]
- Implement Gyro reading functionality [Eric and Padraig]
- Implement Control system design [Padraig]
- Implement VL53L0X functionality [Eric]

6 Bill of Materials

Item	Part Number	Quanitity	Price	Total Cost	Link
Brushless Outrunner Motors	EMAX MT2204	4	$16.99	$67.96	https://www.getfpv.com/emax-mt2204-23
Quadcopter Carbon Fiber Chassis	QAV250	1	$119.00	$119.00	http://www.getfpv.com/blackout-mini-h-q
NXP FRDM K64F Board	FRDM K64F	1	$35.00	$35.00	http://www.nxp.com/products/software-a
Power Distribution Board	TURNIGY	1	$12.31	$12.31	https://hobbyking.com/en_us/turnigy-mul
3S 2200mah Lithium Polymer Battery	FLOUREON	1	$16.99	$16.99	https://www.amazon.com/Floureon-Li-Pol
9-Axis Gyroscope	MPU925	1	$6.43	$6.43	http://www.gearbest.com/sensors/pp_24
ESC Modules	HOBBKYING	4	$7.50	$30.00	http://www.valuehobby.com/power-syste
Carbon Fiber Propellers (4pk)	CRAZEPONY 5x3	1	$12.98	$12.98	https://www.amazon.com/dp/B00UTGAP
2.4 Ghz RC 6-ch Transmitter and Receiver	FLYSKY FS-I6	1	$44.90	$44.90	http://www.valuehobby.com/flysky-i6.htm
Lidar Ranging Sensor	VL53L0	2	$5.29	$10.58	http://www.mouser.com/ProductDetail/ST
			Total:	$356.15	

7 System Schematic Diagram