ILR08: Progress Review 9

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1. Individual Progress

Since the last progress review, I was responsible for switching the ESCs on our drone, loading custom RASL firmware on to the PixRacer, and tuning the PID parameters on the flight controller, starting obstacle detection development, and rebuilding the drone after our first field crash.

1.1. ESC Switch

The current T-Motor AIR40 ESCs [1], like most ESCs, have open-loop PWM control meaning that the flight control provides a PWM input to the ESC to control the motor RPM. The drawback with this is that when the battery voltage to the ESC drops, the same PWM signal would result in slower RPMs. The ESC32 v3 [2] provides closed-loop feedforward RPM control [3]. This is done through calibration of voltage-RPM parameters in the ESC32. Moreover, the second version of the custom RASL [4] firmware makes use of this functionality of the ESC32 for better control than the standard PX4 firmware.

However, this switch adds the overhead of calibrating the ESC32 parameters, and characterizing other motor parameters like thrust/torque coefficients, motor rise times and fall times.

I was responsible for preparing the connections of the ESCs as shown in Figure 1, testing them using a small Servo/PWM tester and mounting them on the arms.

I was able to prepare the connections but we didn't end up switching the old ESCs till after the Progress Review due to delays due to hardware in the calibration process.

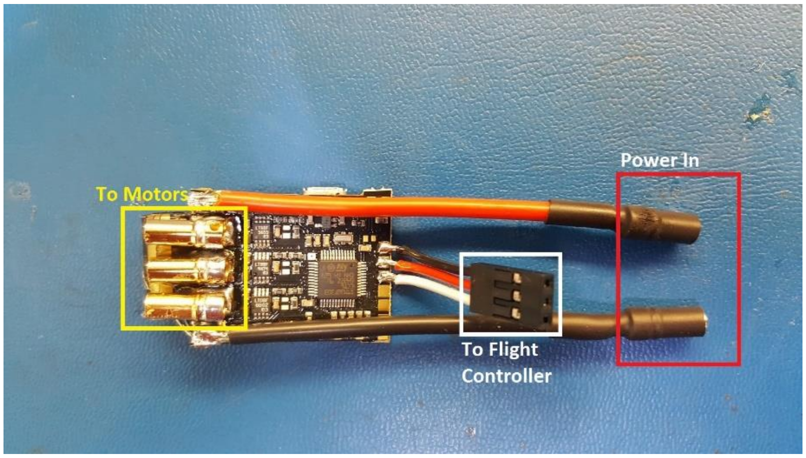

Figure 1: ESC32 v3 [2] prepared for the Hexrotor

1.2. Firmware and Calibration

The RASL lab [4] develops a custom firmware for the PX4 [5] flight controllers with a PID controller for stability. A second version of the firmware also takes into account the vehicle's weight and uses feedforward closed-loop RPM control for each motor on the vehicle. The second version requires using compatible ESCs - in our case the ESC32 v3 [2] and deriving motor model parameters namely thrust/torque coefficients, motor rise and fall times.

I was responsible for working with Moses Bangura [6] on loading the new firmware, calibrating the drone sensors and tuning the PID control parameters of drone Yaw rate, Roll rate, Pitch rate, and thrust.
We were using the first version of the RASL [4] custom firmware as testing the old open-loop ESCs with the second version failed.
We flew the drone in the RASL [4] cage and tuned the parameters by trial-and-error. Although a slight Yaw drift was unable to be compensated for, leading to manual correction every 15-20 seconds to maintain drone heading.

2. Challenges

Challenges were faced in terms of damages. However, due to preparedness with spare parts, we haven't faced a huge delay. For calibrating the closed-loop ESCs, the lab was responsible for using a calibration rig to find feedforward parameters as well as motor characteristics. Unfortunately the calibration rig broke on Feb 23 and delayed the process by one week.
Next, we had conducted multiple dry runs of flying the drone in the lab and tested all sensors. Hence, while conducting the field test, the full system was functional. However, due to extreme winds (11pmh and above), the drone experienced a high disturbance and crashed. The controller followed the RC set points, but did not have the function to compensate for the disturbance on its own. This led to some damages including 2 arms, 4 propellers, 1 sheared camera lens, and minor scratches on LiDAR. The LiDAR was mostly safe due to the 3D printed cap.
Work on obstacle development did not start due to focus on preparing the drone for field test through multiple dry runs and due to efforts in rebuilding the drone after the first field crash.

3. Teamwork

Clare and Logan continued development on the ROS mapping packages "map_utils" and "map_server" and prepared them to accommodate RGB and LiDAR data.
Logan also handled project management, helped prepare the drone for field test, and helped rebuild the drone.
Angad helped the supervisor with covariance estimates for the state-estimation using a form of UKF but mostly left it to the supervisor and the lab. He also set up the udev rules on the drone to assign permanent serial port IDs to each device. He also helped test the GPS fix and update the software on the drone to include MAVROS and get barometer readings from the IMU

4. Plan

After rebuilding the drone, I will be working with Angad on the trajectory planning and obstacle avoidance in simulation before testing out on a small quadcopter in the lab. Clare and Logan will have the colorized voxel grid map up and running. We also plan to have conducted at least

1 more field test to acquire all sensor data and fly the drone around the La Farge quarry for finding the optimum path for best map generation.

References

[1] T-Motor, "AIR 40A ESC," [Online]. Available: http://www.rctigermotor.com/html/2014/esc_1223/285.html.

[2] AutoQuad, "ESC32 Version 3," [Online]. Available: http://autoquad.org/wiki/wiki/aq-esc32/esc32-version-3/.

[3] AutoQuad, "ESC32 Run Modes," [Online]. Available: http://autoquad.org/wiki/wiki/aq-esc32/esc32-general-functions/esc32-run-modes/.

[4] C. Robust Adaptive Systems Lab, "Robust Adaptive Systems Lab, CMU," [Online]. Available: http://rasl.ri.cmu.edu/.

[5] PX4, "PixRacer," [Online]. Available: https://pixhawk.org/modules/pixracer.

[6] "Moses Bangura," [Online]. Available: http://www.ri.cmu.edu/person.html?person_id=4504.