EE CprE 491 – May 1718
MicroCART Senior Design Team
Week 1 Report

October 3 – 9
Faculty Advisors: Phillip Jones, Nicola Elia

Team Members:

Brendan Bartels — *Meeting Minute-Taker*
Kris Burney — *Ground Station Key Concept Holder*
Joe Bush — *Quadcopter Software Key Concept Holder*
Jake Drahos — *Team Webmaster*
Eric Middleton — *Hardware Maintainer*
Tara Mina — *Team Communications Leader*
Andy Snawerdt — *Control Systems Key Concept Holder*
David Wehr — *Team Leader*

Summary for Progress this Week

This week we replaced the motors on the quadcopter with newer ones that work with the same ESC, and verified that the flight of the quad would be similar to before with some simple flight tests. After doing this, we began taking some more measurements of the quad, including measurements for determining the thrust and drag constants with the new motors and the new propellers attached. We continued looking into the quadcopter software and began examining the code for the PID controllers on the quadcopter. In addition, we began looking into how to compile the three main software programs that the quadcopter uses, flash them onto an SD card, and have them run on the quadcopter. In this process we did not make any changes to the quadcopter software, but we went through the process of uploading code to the quadcopter.

Past Week Accomplishments

- Replaced motors on quad and tested flight - Brendan, Eric, Tara, Andy, and David
    - Salvaged motors from abandoned undergraduate research project
    - Took out motors from the quadcopter and replaced them, using the new propellers as well. New motors threaded in such a way that only their dedicated props could be used, unless we get two reverse-threaded nuts.
    - Tested with new motors and flight behavior is acceptable
        - When the battery if fully charged, the stabilization seems as good as before. As the battery voltage decreases, though, the stability gets worse.
            - The new props are slightly smaller than the older props, which could be the reason for decreased stability.
    - Approximately checked the angular rotation speed compared to that of the previous motors, using the tachometer. Results were relatively similar.
- Gathered data for determining the thrust constant with new motors - Brendan, Tara, and Andy
    - Used the set method developed last week - found here

    - Test involved all motors running simultaneously
    - Frequency of 400 Hz
    - Voltage of 3.2 volts peak to peak
    - Offset voltage of 1.6 volts
    - Took data from ~47% duty cycle to ~75%
        - Didn't go all the way to 80% due to the following:
            - Current began maxing out at 20 amps
            - Quadcopter stopped providing additional thrust on the scale
    - Measured the following at 1% increments
        - Force of thrust - measured by scale
        - Voltage provided by the power source - measured by the power source
        - Current provided by the power source - measured by the power source
        - Angular speed of the each prop - measured by tachometer
- Continued following software data flow - Joe, Tara, Andy, and David
    - Continued following the software data flow looking into the following programs:
        - sensor_processing
        - control_algorithm
    - Looked into how the different PID controllers on the system use the same program to keep track of error, and correction values, but this program gets passed in the PID controller object with the information of each specific PID controller, like the controller for the pitch, roll, yaw, x-direction, y-direction, z-direction, and pitch-rate, roll-rate, and yaw-rate
    - Realized that there would be 27 different PID constants to find for the controls team:
        - 3 constants for each PID controller (Kp, Ki, and Kd)
        - 3 degrees of freedom for each vectorized quantity representing movement (3 for stationary position rotation including pitch, roll, and yaw, 3 for linear position, including x-direction, y-direction, and z-direction, etc.)
        - 3 vectorized quantities representing the movement of the quad that we will control with a PID controller, including:
            - Angular position of the quadcopter (pitch, roll, and yaw)
            - Angular velocity of the quadcopter (pitch rate, roll rate, and yaw rate)
            - Linear position of the quadcopter (x-direction, y-direction, and z-direction)
- Continued looking into Matt's thesis, reading and clarifying points - Brendan, Tara, and Andy
    - Continued reading relevant sections of Matt's thesis, specifically the sections associated with thrust and drag constant calculations and measurements.
    - Looked into formulas describing the percent battery voltage used by the motor, which depend on the following parameters
        - Minimum percent duty cycle
        - Maximum percent duty cycle
        - Battery voltage
        - Current percent duty cycle
    - Clarified the meaning of certain parameters that represented the percent duty cycle, since percent duty cycle can be represented in two ways:

        - The absolute percent duty cycle, as defined by the function generator, using the period of the PWM signal for reference
        - The relative percent duty cycle, converted to be a percentage of the total possible battery voltage available for the
- Created MATLAB scripts for processing data for measuring thrust and drag constant - Andy
    - Input: takes in an absolute path to an Excel file where all of the data is recorded
    - Output: drag constant and thrust constant
    - Parses the data in the Excel file into a table format
    - Performs calculations on the data as described in chapter 5 of Matt's thesis
    - Works well, has been tested with data recorded
    - Only need some parameter constants from Ian to calculate final values from our data
- Created document template for Project Plan 1 - Tara
    - Added into the Google Drive folder for easy access and editing of the group
    - Includes all of the features listed out in the rubric of the assignment
    - Also includes some features included from several of the previous years' MicroCART project plans
    - Began adding detail to the several of the sections, including the Introduction and Conclusion, and began specifying parts of the Testing and Deliverables sections
- WiFi - David
    - Finished code for ESP8266 chip to forward serial over TCP and vice-versa.
        - It is now reusing TCP connections between sending, resulting in even lower latencies: 1.5ms round-trip network time, down from 2.2 when the socket was being re-created for every request.
- Building Quad Software - Eric, David, Brendan, Joe
    - Successfully opened and compiled the hardware configuration project in Xilinx Platform Studio (XPS)
    - Exported the hardware configuration into the XSDK, created a board support package, compiled the software, and created a boot file.
    - We are able to boot last year's software on the quad and make changes to it (via flashing an LED), but it seems to crash somewhere in the initialization.
- Ground Station - Kris
    - Modified existing Bluetooth proof of concept code to perform more like a command line interface
        - Thread for receiving VRPN data from jakes computer
        - Thread for accepting commands from User via stdin
        - Thread for acting upon updates that occur within the other two threads
    - Starting to add a command structure to the code. Adding commands to be recognized.
        - Setroll, setyaw, setthrottle, setrollp, setrolld, setyawp, setyawd … etc.

Pending Issues

- Moment of Inertia measurement - Brendan, Tara, and Andy
    - Still need to come up with a reliable way of measuring moment of inertia as the current ideas have specific issues associated with them.
        - Method 1: Providing a relatively "known" torque generated from the quad itself.

        - Issue 1: This “known” torque is mathematically calculated based on the thrust and drag constants which were also experimentally obtained. This means that the error in the moment of the inertia is accumulated through through the thrust and drag constants error.
        - Issue 2: This requires specific software that allows us to know exactly what input we are applying.
        - Issue 3: We cannot power the quad directly off of a power supply for this test, meaning the voltage applied will change overtime creating more error in our results.
      - Method 2: Providing a known torque through a mass and pulley system.
        - Issue 1: The major issue with this is in the actual setup. Unless we can drop this mass from a very high location, we can only produce a known torque for a limited window of time, which limits the amount of data we can collect. Less data accumulation means more error associated with the tests.
    - Have talked with Lee Harker, who may possibly be able to fix the current ECP machine
      - Need to schedule a time with him at this week to go into the lab to look at the machine
      - A better alternative than sending the machine to be repaired by the company itself, or buying a new machine, both of which are very expensive solutions
- Trouble getting our re-compilation of the current quad software to run
  - Seems to hang in the initialization function
- Current ground station computer has been fixed back to it’s previous glory. Either a result of fixing or a result of the original issue is that rfcomm no longer exists on the computer. The service is not runnable currently. This will be looked into and solved ASAP.

Individual Contributions

Team Member	Contribution	Weekly Hours	Total Hours
Brendan Bartels	Thrust and drag constant, Motor replacement, Quad Programming	8	27
Kris Burney	Ground Station command line interface preparation and setup. Command structure and adding of registered commands.	18	56
Joe Bush	Quad code flow, started learning toolchain	10.5	35.5
Jake Drahos	Very little	2	25
Eric Middleton	Motor replacement and flight testing, quad hardware/software compiling	18	54
Tara Mina	Thesis, measuring thrust constant, replacing motors, arrange and start project plan document	12	47
Andy Snawerdt	Thrust and drag constant measurements, documentation, and MATLAB scripts. Motor replacement, Matt’s thesis, and ECP mounting change.	15	55

David Wehr	Quad Software and Hardware compiling, WiFi communication replacement, mapping data flow, replacing motors	14	50

Comments and Extended Discussion

This week, we had to make a few important decisions to decide what the best course of action for our team would be at this point. The issue we had was that one of the motors on the quadcopter was broken, and these motors are a type that are not currently being manufactured any longer, so finding replacements for them is not as simple as it used to be, though it is definitely not impossible. At this point, we were trying to consider what we should do to continue making progress as efficiently as we can with reasonable consideration of our short-term and long-term goals.

So we began to consider the future of this project as well, finding that it seems we will eventually need to replace the motors with new ones, since they are parts of the current system that will break, get old, and generally need to be replaced the most, so we will want readily available replacements. Thus, we could find a new motor of the same type, and wait for it to come before continuing with our measurements, or we could replace the motors with the newer more available ones, check to see if it works the same or almost the same, since it should in theory, and then continue our measurements if everything for the quadcopter using the new version of the motor. We went with the second option, since we understood that it would be very easy, if we change our mind later, to convert back to the original version of the quadcopter with the original motors, for all we would have to do is swap out the new motors with the original ones and purchase a fourth motor of the original kind.

Plans for Coming Week

- Finish Project Plan 1 - All team members
    - Due for EE 491 course by the 14th of this week
    - Currently have basic template set up
    - Will use several of the previous teams' project plans for reference
    - Come up with Deliverables, and compartmentalize this into different sections according to the "portions" of the quadcopter project:
        - Controls Systems
        - Quadcopter Software
        - Ground Station
    - Draw out a timeline, one for the fall semester and another for the fall semester
    - Create a test plan for assessing our solution and determining whether our realized solution is within the acceptable limits as defined by our goals or requires further work/improvement
    - Define requirements and specifications for our project - including functional and non-functional requirements
    - Predict some challenges that we may experience, including risk and cost considerations
- Get values of the drag and thrust constants – Brendan, Tara, and Andy
    - Currently have all of the data we need for this in the proper format for the Excel file that the function will bring in for performing calculations
    - Must get a few parameters, which are necessary for our calculations, from Ian

- Arrange a time with Lee Harker to go to the lab - Tara and Andy
    - Must arrange a time with Lee to have him look at the ECP machine
    - Lee may possibly be able to fix the current ECP machine, which would give us a source of constant torque for doing moment of inertia measurements
    - Lee needs to check the machine to see if he can, first of all, possibly fix it
        - If he cannot, may try to talk with a different department, like the physics department or the aerospace department
        - Probably will simply look into our other methods of creating a constant torque, using the self-generated torque from the rotors on the quadcopter itself, or using a mass and pulley system
- Quad software
    - Get current software to compile
    - Figure out how to debug over JTAG
    - Modify it to echo camera data, for measuring latency
- Ground station
    - Review/reimplement previous ground station software (CLI)
        - Add commands that are recognized by CLI and implement to send proper packets to quad side.
- Website - Jake
    - Get dependencies installed, layout site structure + git…
- WiFi
    - Create networking code that can be integrated into base station for communication over WiFi

Summary of Weekly Advisor Meeting

This week we mostly talked about some of the issues we are having, including the issues we are having with the ECP machine and finding a way to create a constant, known torque for doing moment of inertia measurements. Another issue we were having was a broken motor on the quadcopter, which we discussed with the team our possible next steps with respect to this issue. Additionally, the base station team discussed their issue with getting logging data back from the quadcopter, since they did not seem to get any. At the end of the meeting, Dr. Jones discussed some general things we should be doing as a team working on this project over the next couple of semesters.

- ECP machine problem - alternatives to creating a constant, known torque:
    - Control team's suggestions after discussing with Matt Rich:
        - Use propellers to generate a known torque based on the thrust constants
        - Can still use the encoders of the ECP machine to measure the displacement angle
    - Dr. Elia's suggestions:
        - Fix and still utilize the ECP machine, if possible
        - Maybe we could apply a current generator to apply a known torque
- Broken motor on the quadcopter - our next steps
    - Controls team still needs to be moving forward
    - Andy's suggestions after discussing with Matt:
        - Could salve motors on the other quadcopter
        - The motors on the other motor are similar

            - Both use 30 Amperes
            - May have different thrust constants
                - Important for calculating moment of inertia, if we choose to use the thrust constant for creating a known, constant torque
                - If we do not have usable motors, we will lose time with taking data for the moment of inertia
                - May have to retake the same data again later if we make changes to the motors in the future, can prevent this if we switch motors now instead of later when we might need to
    - Dr. Jones's concerns:
        - Want to avoid swapping stuff out unnecessarily, because we cannot predict what changes might occur
        - Though, it is true, that we can switch out the motors and easily switch them back if needed - if things do not work the same way
- Updates from the base station team and their work
    - Dr. Jones's comments:
        - Understands the frustration with the compiler tools, and it seems like the base station team is adapting well
    - Team's updates:
        - Status report has some issues
        - Not getting all of the data that the team is expecting
            - May mean that there is an issue with the quadcopter
            - Or may mean that things are not being logged correctly
    - Suggestion from Paul about the issues being experienced:
        - Data is not supposed to come back if you are not in autonomous mode
        - Wi-Fi might allow you to send all of the data, rather than only doing logging during autonomous mode
        - Next step: Try putting it in autonomous mode and see if you get data back
    - Dr. Jones: What do you mean by "time stamped reviews to handle packets" ?
        - Jake responds to this question:
            - Using the timestamp as a unique identifier
            - Having trouble identifying which packet was which going to and from the quad, this is how we were going to differentiate between the packets
    - Dr. Jones: What do you mean by "FPS calculating far from ideal" ?
        - FPS is frames per second
        - Jake's response: Ian said it was useful to have, so we added it
        - Paul's thoughts: it is useful to know, possibly, if you have problems with packet drops
        - Dr. Jones's thoughts: should be sufficient to simply log the time difference
- General suggestions from Dr. Jones:
    - Team needs to eventually start working together more closely as one team
    - Should not divide into too many small groups without communicating with the other members
    - Need sub-teams to replicate the pendulum controls exercise

- Requires use of C code, PID tuning, and Joe Avey’s VHDL hardware
- Should mix up the typical teams
- Do it concurrently while we continue working on the quadcopter stuff