EE CprE 491 – May 1718
MicroCART Senior Design Team
Week 7 Report

October 17 – 23
Faculty Advisors: Phillip Jones, Nicola Elia

Team Members:

Brendan Bartels — *Controls Software Key Concept Holder*
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 focused on trying to move on to the next step in order to continue progressing on developing the rigorously-determined PID controller constants. Now that we have found most of the quadcopter parameters, we need to start developing our Simulink model, because the next step once we finish the identification of the quadcopter is to start running simulations with the PID controllers we design for controlling each of individual movements of the quadcopter, including pitch, roll, yaw, pitch rate, roll rate, yaw rate, x position, y position, and z position. In addition, round trip testing of latency has been tested with the start of the new ground station code.

Past Week Accomplishments

- Met with Physics Department – Brendan, Tara, and Andy
    - Met with Dr. Paula Herrera-Siklody, the Physics Department Lab Coordinator
    - Visited their lab to see what their moment of inertia set-up was like
        - Had 2 mass-pulley systems and both worked similarly and had the following components:
            - A **dropped mass** being pulled by gravity acts as the known torque rotating the moment of inertia
            - A piece of **string** connected the dropped mass to the rotating platform
            - A **pulley** guiding the string connecting the rotating platform to the mass, rotating with little friction
            - A **software program** called LoggerPro that is set-up to take data easily and automatically for post-experimentation analysis
        - 1st mass-pulley system had a narrow, horizontal rod for a spinning "platform"
            - Would be difficult to mount the quadcopter onto and keep balanced
            - Meant for smaller objects, not necessarily our quadcopter
        - 2nd mass-pulley system had a flat, circular plate for the spinning platform
            - This is very similar to what we had with the ECP machine

- - Much easier to mount the quadcopter onto, especially for yaw, where the quadcopter is positioned flat
    - Can use some clamps and rods to help support the quadcopter when we want to position it for roll and pitch, where the quadcopter is on one of its sides
- Began Creating Simulink Template – Andy
  - Primarily fleshed out the overall structure of the model based off of the information located in section 3.2 of the project plan.
- Began Design Document – Tara
  - Start creating Design Document Template
    - Based on basic template provided by course
    - Uses some of the structure present in previous year's design document as well
  - Began adding information to most of the sections
- Started Documentation for Measuring Motor Resistance – Tara
  - Began creating a document describing the procedure we went through to measure the motor resistance
  - Talked about what the motor resistance is and how it would be physically measured it from the motor pins
  - Showed a more accurate way to measure it using a Wheatstone Bridge
  - Described the setup process with lots of detail
  - Gave some optional steps and advice for easier measurement process
- Started Quadcopter Software Diagram – Brendan
  - In order to correctly implement the controller model, the controls team will need to know how sensor and positional data is handled and manipulated in the quad. The objective of the diagram is to help visualize how that data is handled/manipulated.
  - Create a software diagram based on function calls.
    - Focus on capturing the data flow from sensors and receivers to processing code.
    - Summarize code functions at each stack frame
  - The first pass was nearly completed
- Began writing socket code for Linux – David
  - Using only TCP for now
  - Writing it as an external module that will return a file descriptor to be used within the select command.
  - Need to add a keep-alive message that will be periodically sent to quad to detect a dropped/closed connection
    - If connection has been dropped, will automatically re-open to enable sending/receiving on the socket.
- New Ground Station round trip latency testing - Kris
  - Starting when vrpnPacket is sent
  - Padding vrpnPacket to 32 bytes
  - Average latency = 69 ms
  - Max latency   = 116 ms
  - Median latency = 68 ms

- Investigating asyn(through select) log writing and stdio handling - Kris

Pending Issues
- Currently no major issues, will most likely change soon…

Individual Contributions

Team Member	Contribution	Weekly Hours	Total Hours
Brendan Bartels	Physics Dept Meetings, Control Software Diagram	9	46
Kris Burney	GS > Quad > GS latency tests	4	68
Joe Bush	Meeting, setting up tools	6	52.5
Jake Drahos	Ground Station, latency testing	4	35
Eric Middleton	Ground Station, latency testing	4	69
Tara Mina	Physics Department, Measure I_f, Design Document, Motor resistance documentation	10	65
Andy Snawerdt	Physics Department, Simulink Model Development	5	69
David Wehr	Socket code for Linux	5	57

Comments and Extended Discussion

This week, we really want to move on with starting to do some implementation and design work. We want to be able to make sure we have plenty of time next semester to do some cooler, more impressive implementation during EE 492. So, to make sure we can do this, we want to make sure that MicroCART is in a good state by the end of this semester, so we want to start getting some fundamental elements in place by the end of this semester, including the ability to do autonomous flight. Thus, we want to start doing testing through our simulation of the quadcopter system, this way we can get to implementing the control system on the quadcopter more quickly, and have plenty of time the rest of this semester to fine-tune these abilities so that they are in a solid state before the start of next semester.

Plans for Coming Week
- Finish Design Document 1 – All team members
  - Need to finish coming up with more detailed function and non-functional requirements as well as our design analysis procedure
  - Need to edit and condense some of our previous descriptions for each of components for the deliverables
  - Must come up with detailed testing procedures for our design
- Work with the Moment of Inertia Equipment – Brendan, Tara, and Andy
  - Will meet again with Dr. Herrera-Siklody to practice using the current set-up for measuring the moment of inertia (which is described in detail above in "Past Week Accomplishments")
  - Practice recording data using the LoggerPro software available
  - Dr. Herrera-Siklody will help us find a sturdy, usable pulley for the larger rotating platform, since this set-up has not been used as much recently
  - Also will practice running the moment of inertia tests for known moments of inertia

- o Will gather materials we will need to do our measurements for pitch and roll as well (as described above in "Past Week Accomplishments")
  - ▪ Get moment of inertia measurements – Brendan, Tara, and Andy
    - o Continue working with the Physics set-up (as described in detail above in "Past Week Accomplishments")
    - o Once we get comfortable with this set-up, can start taking yaw moment of inertia measurements with it
    - o After getting the yaw moment of inertia, start using clamps and rods for mounting the quadcopter on its side but still along the axis of rotation for taking the pitch and roll moment of inertia measurements
- · Finish documentation explaining how to measure the Motor Resistance – Tara
  - o Need to take some good pictures that will help show more clearly how to do the different steps enumerated in the procedure sections
  - o Need to describe how to balance the Wheatstone bridge
  - o Include our results/data from our tests, possibly, for an example to reference for each step of the data collection
- · Continue quad software diagram as time permits – Brendan
  - o Complete control section, and be sure all data flow sections have sufficient details.
  - o May move onto rest of code.
- · Finish linux socket code (for real this time) - David
- · Extended work on discussed Ground Station(BE + FE) plan - Kris, Jake
- · Implement Wifi on Ground Station - Kris, David

Summary of Weekly Advisor Meeting

This week, Dr. Jones looked over our first Project Plan document and gave us some pointers for how to improve and change it for the second version. Additionally, Dr. Jones gave us some advice for how we should be documenting what we are doing for developing a good website and Wiki page at the end of the semester for future teams to be using and referencing. The ground station team discussed some of the issues they have been seeing with the current state of the code, which is not thread-safe, and explained their idea for creating an event-based method.

- ▪ Recommendation from Dr. Jones for documentation:
  - o Take pictures and video of the things you do
  - o Archive these pictures and videos, keep them in an organized location, and highlight them on the webpage
- · Template for website is up
  - o Can start adding content
  - o Need to get this in a good state before the due date for our team website
- · Make sure we are adding to the Wiki page, as well
  - o Do not want to repeat the mistakes of last year, when the team dropped the ball on the Wiki page
  - o Want next year's team to be able to reference our Wiki page as well as our website
- ▪ Project Plan comments from Dr. Jones:
  - o Looks good for a first draft
  - o Section 2 needs more figures and diagrams

- o Section 3 has a lot of good diagrams in the first half (controls section), but needs more diagrams for the second half
- ▪ Update: Found a workaround for the UART issue
  - o Joe Avey tried to compile last year's program and could not
  - o Do not have any copies of code that compiles properly, that we know of
  - o Joe Avey looked at last year's code and had some thoughts:
    - ▪ The issue of not being able to compile seemed familiar
    - ▪ But, he cannot remember how he fixed it
    - ▪ He believes that it should be an easy fix, though
- ▪ Need to know latencies for the controls team
  - o Do not have a good method to get latency from the camera system to ground station
  - o However, it is possible that this camera system latency is negligible compared to the other latencies that we have in the system, can possibly ignore it
  - o Can make a good controller without this, but would be important to know if it is large
  - o Can make a simple test with an IR LED to test the latency if we want
- ▪ Updates about Bluetooth communication
  - o Base station was down before
  - o Ian and Kris fixed it last week
- ▪ Ground station: adapting old code (MicroCART CLI from last year)
  - o Kris is working on the CLI (command line interface) stuff
  - o Should be structured as a simple loop
    - ▪ First, will get a user input
    - ▪ Then, send command to the quadcopter
    - ▪ Finally, log data from this iteration
    - ▪ Then, start over again
  - o Issues with the logging module:
    - ▪ Module is not thread-safe
    - ▪ Changes to make:
      - ● Will instead listen over the console, over the socket
      - ● Will run as a "daemon" in the background the entire time
      - ● Previously, file descriptors were being managed poorly
      - ● In short, refactoring needs to be done
    - ▪ Possible issues if not fixed:
      - ● Main thread and VRPN monitoring threads can possibly both write at the same time to the same point of the data
  - o Event-driven model updates:
    - ▪ "Select" calls are being added by Jake to make this happen
- ▪ Latencies that controls team needs to capture
  - o Do not need to worry about a lot of the ones explicitly stated in Matt's thesis (as described in last week's report), because unlike Matt's quadcopter, our controller is on the actual quadcopter system, so the latency is very, very small
- ▪ Should make sure we use a good baud rate, not too high, so that we avoid dropping packets
- ▪ Updates from individual team members:
  - o David:
    - ▪ Mostly worked on Project Plan

- Memory leaks in current software, trying to fix this
  - Not completely certain, need to explore some more
  - But, according to Dr. Jones, there have been memory leaks in the past
  - Should ping Joe Avey to learn more about the memory leak issue
  - For upcoming week:
    - Want to write socket code
    - Want to take measurements for latency timings
- Andy/Tara:
  - Worked on project plan mostly
  - Measured motor resistance values
  - Used a wheatstone bridge to do these measurements, since the motor resistance values are so small
  - Dr. Jones's recommendation: write up the procedure for how we went about using a wheatstone bridge to get the motor resistance value
  - Will meet with the physics lab coordinator this week to check out the setup available for doing moment of inertia measurements
  - Using the measurement we got for the motor resistance, found the kd constant
  - Andy started creating the Simulink model
  - Will continue to develop the model
  - Dr. Jones's recommendation: make the model a modular one, use subsystems
  - Matt Rich's recommendation: use the "add code in block" feature, do not want a big mess of blocks for each equation we are using
- Jake:
  - Continue changing ground station to an event-structure using "Select" calls
  - Focus on refactoring the ground station program
  - Dr. Jones's recommendation:
    - Do documentation of these actions and improvements, mentioning the common mistakes you are seeing and fixing
    - Look at the previous team's structure for the website design and layout
- Brendan:
  - Worked a lot on the project plan this week
  - Did proofreading and editing of most of the document
  - Practice building last year's project
  - Practiced programming the board
  - Continued working on the code diagram flowchart of data
- Eric:
  - Mostly worked on the project plan
  - Worked on quadcopter software
  - Want to get the logging working in real-time
  - Current system does not log until the quadcopter is armed
  - Plan to be available to help the ground station team
- Joe:
  - Worked on the project plan mostly

- Tried to get the code to compile
- Dr. Jones expectations for next week:
  - Some basic demoing with the CLI
  - Basic Simulink model developed