EE CprE 491 – May 1716
MicroCART Senior Design Team
Week 3 Report

September 19 – 25
Faculty Advisors: Phillip Jones, Nicola Elia

Team Members:

Brendan Bartels — *Recorder*
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 began taking some basic measurements for system identification of the quadcopter. In addition, we started looking more closely at the software that takes in sensor data from the IMU and gyroscope to gain a systems-level understanding of how the data is being changed and processed in the entire program

Past Week Accomplishments

- Took measurements to determine yaw-axis moment of inertia - Brendan, Tara, and Andy
    - Arranged a time with Ian for this first measurement run, to make sure everything is setup properly to prevent damaging the quadcopter and obtaining inaccurate data from performing an improper measuring process
    - Mounted quad onto the ECP machine plate with lots of duct tape, making sure the quad is centered on the axis of rotation, so that its yaw axis is approximately aligned with the axis of rotation
    - Ran a step input and took measurements with ECP machine
        - Took measurements at 5 different input voltage values, which represent the voltage given to the spinning motor rotating the quadcopter
        - For each input voltage value, we did 3 runs, each lasting 5 seconds
- Took calibration measurements for ECP machine - Brendan, Tara, and Andy
    - Before analyzing the measurements to determine the yaw-axis of rotation, we had to also measure the moment of inertia of the ECP machine itself, without the quadcopter, in order to calibrate our data appropriately
    - Ran a step input and took measurements with the ECP machine
        - Took measurements at 5 different input voltage values, each voltage value having 3 runs, and lasting for 5 seconds
        - These input voltage values were smaller than the previous values we used since the lack of moment of inertia creates a much larger angular velocity for

the same amount of torque, eventually causing the ECP machine to cut-off the run

- Began mapping out data flow in quadcopter software - Brendan, Joe, Tara, Andy, David
    - The controls team needs to have a strong and detailed understanding of how the data is being manipulated as different modules of the code process it. The control system will be designed from a mathematical model representing the quadcopter, so it is important to know at any given time what form the data has taken, and what it physically means
    - We found the directory of the files with functions that bring in and process the quadcopter sensor data
        - In the file iic_mpu9150_utils.c we found the function get_gam_reading which does the following, in short:
            - Takes in a pointer for a *gam_t* struct, called *gam*, where the received data will be stored
            - Reads in acceleration and gyroscope data values from the sensors
            - After configuring the different data values to specific ranges (multiplying them by the appropriate scalar factor), save to the *gam* struct
        - In the same file, we found another function called ReadMag, which does basically the same thing as get_gam_reading, but for the magnetometer data
    - Have started sketching and recording this information in block diagram format, which will eventually become made into a powerpoint presentation
- Clarify certain concepts in Matt's thesis with Matt himself - Brendan, Tara, and Andy
    - Some of the physical expressions were a bit difficult for us to gain a good, intuitive understanding of, even after discussing it amongst ourselves, so we went to Matt
    - A few of these concepts include:
        - Expressions relating a position vector in the body frame of reference and the body angular velocity vector to a linear velocity in the body frame
        - The earth frame of reference matrix - we basically thought this would be the identity matrix, since "earth is the absolute frame of reference", but Matt explained that although it was "pedantic" he defined earth in an even more absolute, "magical" frame of reference
        - The derivative of the body-to-earth transformation matrix being equivalent to a multiplication of a skew matrix
- Minimum base station design - Eric, Kris, Jake
    - Design bare minimum base station in C
        - VRPN client - Jake
            - C++ interfaces with VRPN library, exposes C interface
            - Complete, tested
        - Bluetooth communication - Kris, Eric
            - C, using BlueZ linux library (no more shell scripts)
            - Successfully connected to quadcopter with test program
- WiFi Latency - David Wehr
    - Measured TCP latency
    - Tested WiFi with interference in lab

    - Updated documentation with new results
- Team roles determined - All team members
    - Met this week to discuss who should be placed in the different roles listed to us by the senior design course directions, as listed above
    - Also discussed what additional roles we wanted to delegate, including the following:
        - Key concept holders of specific portions of the project:
            - Quadcopter Software (Joe Bush)
            - Ground Station (Kris Burney)
            - Control Systems (Andy Snawerdt)
        - Hardware Maintainer (Eric Middleton)
            - Will be in charge of making sure that the hardware is in good condition
            - Help make improvements to the hardware as needed
        - Recorder (Brendan Bartels)
            - Will take notes during meetings
            - Email the notes after the meeting to the team

Pending Issues

- Can not locate the mounts for taking measurements with ECP machine - Brendan, Tara, and Andy
    - Need mounts to hold the quadcopter secure in different positions when taking measurements with the ECP machine, especially
    - Searched the lab, as well as the cabinet in the corner, for a bag of mounts
    - Ian didn't know where they were, we asked Joe Avey as well, but he did not know where they were either
    - For now, this should not be too much of an issue, since we will just measure the moment of inertia of the quadcopter about the pitch and roll rotational axes, and we have figured out a different way to mount the quadcopter that will not need extra mounts

Individual Contributions

Team Member	Contribution	Weekly Hours	Total Hours
Brendan Bartels	Matt's Thesis, Data collection, meetings	6	14
Kris Burney	Understanding Bluetooth, handling vrpn data	7	23
Joe Bush	IMU dataflow, trying to figure out code structure	7	11
Jake Drahos	Ground Station (VRPN and Callbacks)	7	18
Eric Middleton	Ground Station (design, bluetooth testing)	6	29
Tara Mina	Matt's thesis, ECP measurements, data flow	8	24
Andy Snawerdt	Matt's thesis, ECP measurements, data flow	10	25
David Wehr	WiFi latency testing, Quad data flow investigation	8	27

Comments and Extended Discussion

This week we have begun taking data, and looking much more closely at the code and mapping out the details, which has helped us start getting a much better understanding to how the quadcopter system is works. Some parts of the quadcopter system that have previously been fuzzy are now becoming more well-defined, with the type of data entering and leaving each functional block and the data connections between different functional blocks giving a systems-level perspective to represent the system.

Plans for Coming Week

- Take measurements for moment of inertia with ECP machine - Brendan, Tara, and Andy
  - Want to take measurements about the pitch and roll axes of rotation, as well
  - Came up with a different way to mount the quadcopter to do these measurements, which will help make sure the center of mass of the quadcopter is centered on the axis of rotation
- Continue getting software flow diagram - Brendan, Joe, Tara, and Andy
  - Look into the sensor_processing file next, which is the next place the data goes to after it is brought in from the sensors and has basic scaling and calculations performed on it
  - Create basic Powerpoint slides summarizing the data flow connection between the hardware (sensors) and the software representation (data structs)
- Look for or create MATLAB scripts parsing data from ECP machine - Brendan, Tara, Andy
  - Want to find some MATLAB scripts that have already been written by previous teams to bring in the data recorded by the ECP machine to the MATLAB workspace
  - Once we find these scripts, need to read through them and test them to make sure they still work on our data text files, since according to Matt, they have not been used in a while
  - Make any necessary changes to the code, update it, and improve it, as needed
  - If cannot find the scripts, or if they are not working well at all, re-create the scripts
- Communication Latency - David Wehr
  - Test current Bluetooth latency
  - Test WiFi on Linux
  - Begin implementing WiFi into simple base station
- Ground Station - Kris, Jake, and Eric
  - Implement bluetooth connection system as a modular library
  - Implement previous team's communication protocol with our bluetooth system
  - Create WiFi connection system as a drop-in replacement for bluetooth
  - Added low-latency callback interface
  - Wrote C interface to allow other ground station modules to work with VRPN
  - Tested both polling and callback interfaces

Summary of Weekly Advisor Meeting

This week with available members of the team, Dr. Jones, Dr. Elia, and Ian, we discussed procedures we should be taking as a group to keep the team, including the advisors and previous team members

who are helping us, updated with our progress. We also discussed some next steps we want to take for this coming week, and in the near future.

- After each meeting, create a document of Meeting Notes and send them to the team
    - Do this the evening after of each weekly meeting
    - This will probably be done by the Recorder in future weeks, a new role we created and delegated to Brendan Bartels this week
    - These meeting notes should include a section of our plans for the coming week
    - When these meeting notes and plans are sent out, Dr. Jones will then be able to verify that we are all on the same track
    - Another suggestion after each meeting: our team should meet briefly (maybe about 10 minutes) to discuss plans and figuring out who will do what for the next coming week
- Note for the future: be careful about "redoing" things
    - We should take an iterative approach to redoing things
    - Be careful not to do irreversible changes, in case your newly improved ideas don't work
    - Don't want to end up in a situation where neither the old nor the new works, especially when the old was already working
- Email Dr. Jones (and the team) more often
    - Send updates to the team throughout the week, don't wait until the weekly meeting to share what you have been doing and making progress on
    - It is important to keep the team updated on the current state of the project, as well as the current issues we are having
    - It is also important for Dr. Jones, at least these first few weeks, to make sure we are going in the right direction and finish things
- Next steps:
    - Wifi latency
        - Create a simple C program that gets camera data and forwards it to the quad
        - Ideally: want the quad to maintain its current position using only the IR tracker
        - Measure the current Bluetooth latency
    - Add advisors to Trello
    - Modeling the data flow through the software modules:
        - Controls sub-group should meet with the quadcopter software sub-group to figure out:
            - Where the data flows
            - What is happening to it at each point
        - Should create a chart (block diagram) showing the data flow information
        - Especially focus on the interface between the "real" world (hardware, sensors) and the "software" world (data structs, represented in the code)
        - Take special note of the conversion between physical parameters and software data types