EE CprE 491 – May 1718
MicroCART Senior Design Team
Week 10 Report

November 7 – 13
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 tried to characterize the sensors on the quadcopter by doing some testing of the accelerometer and the gyroscope, when the IMU on the quadcopter is stationary and flat. To do this the controls sub-team worked with David, a member of the quadcopter software sub-team, to edit the code to properly log the raw information from the IMU sensors directly. After a bit of simple analysis on this data, we characterized the data output from the sensors by simply looking at the variation of the data from what its expected value should be. This work is important for the next step in developing the model for the quadcopter system, which is to develop the Sensor block, a part of which includes characterizing the corruption of "real" position information from our sensor measurements.

Past Week Accomplishments

- Got data for noise characteristics from IMU – Brendan, Tara, Andy, and David
    - David helped the controls sub-team with this by enabling us do the following:
        - Edit the code to receive the raw IMU data
        - Also log a time vector that records the relative time that each data value was taken, which would be useful in case we want to look at the frequency characteristics of the noise later
        - Compile this software, with the changes, onto the SD card.
    - Initially tried to send the data via WiFi, but had issues receiving the data properly
        - Some data values were being dropped randomly, when looking at the logged data after each test run.
        - After some examination, it appeared that this problem was from the WiFi module that David wrote
        - David tried to debug the problem, unable to determine the issue, so we decided to switch methods for data collection

    - Instead, tried receiving the data directly, through a wire connection, instead of via WiFi
- Analyzed the data obtained from the IMU for noise characterization - Tara and Andy
    - Calculated the mean, standard deviation, and variance of the accelerometer and gyroscope data for the X, Y, and Z axis.
    - Plotted the data of the accelerometer and gyroscope for the X, Y, and Z axis.
        - Noticed that the gyroscope noise was isolated to 3 unique values for each axis
        - Believe this is due to the resolution of the gyroscope.
    - Checked results obtained with Matt Rich to ensure they make general sense
    - Larger offsets errors than we were expecting, Matt also finds this unusual, but for now we will continue to use these characterized values to represent our sensors
    - Followed Dr. Jones's suggestion of checking if the values are coming from a tilt in the IMU using MATLAB
        - Determined that a possible tilt is not the only thing that is affecting the deviation of the data obtained from the nominal value
        - From our MATLAB analysis, found that the IMU was measuring a gravity vector that was consistently too small in value by about 3.4%
- Continued working on the sensor block of the model - Tara and Andy
    - Implemented noise of the IMU to the model, this however is toggleable in the model so that testing without noise implemented is also possible.
    - Attempted to characterize the noise in the frequency domain
        - Determined that the magnitude of the noise variation was negligible
        - The offsets, however, were not negligible and we have implemented the calculated values into our model in the sensor block
        - Will double-check our work and assumptions with Matt
- Working on setting up pendulum balancing system for team to practice PID tuning - Joe
    - Reviewed 488 lectures on PID tuning and practiced with simulators
    - Read Joe Avey's PID tuning guide
    - Downloaded past team's pendulum project, working on getting it to run on the FPGA
    - Started a setup guide for the pendulum project
- Began working on Project Plan Version 2 - Tara
    - Included some of the changes specified in the evaluation comments for our first version of the Project Plan, which was done about a month ago
    - Started some basic "clean-up" of the document:
        - Updated some incorrect references
        - Began eliminating some redundancies between sections, like functional requirements repeated in two sections for two quadcopter sub-systems
        - Included some concrete details to several vague functional requirements
        - Added a section clarifying some of the acronyms, added a few to the list
- WiFi Latency - David, Kris
    - Discovered issue with WiFi bridge that resulted in lost data. Fixed it.
    - Some data seems to be getting corrupted before being received by the quadcopter (see "Pending Issues" for more details)
- Ground station - Jake, Kris
    - Laid out software architecture for front-end

    - Began implementing connection between front-end and backend
    - Began implementing CLI front-end
- Hardware upgrades - Eric
    - ESCs
        - Looked at recommended DJI ESCs ("tuned propulsion system"). Existing firmware seems lacking, does not support custom firmware
        - Found new ESC: Flyduino KISS 24A
            - 24A continuous (compared to 15A for the DJI)
            - 125Khz update loop
            - Reports telemetry data: voltage, current, total current use, motor RPM, temperature
            - Supports faster PWM rates (oneshot42 and oneshot125)
    - Old battery disposal- they can be dropped off at Gilman or Durham
    - Found LiPo safe charging sack and storage container

Pending Issues

- Data corruption with WiFi bridge - Kris, David
    - Some data seems to be getting corrupted before being received by the quadcopter
    - This results in some packets claiming they are thousands of bytes long, which is messing up all the timing
    - Cannot replicate corrupted data in standalone tests
        - May have something to do with the pattern that we are sending data, or a different UART interface

Individual Contributions

Team Member	Contribution	Weekly Hours	Total Hours
Brendan Bartels	IMU data analysis	2	64
Kris Burney	Ground station, WiFi latency	5	88
Joe Bush	Reviewed Brendan's diagrams, started pendulum project setup	10	74
Jake Drahos	Ground station - front end	5	48
Eric Middleton	Hardware upgrades	6	86
Tara Mina	IMU data analysis, model, project plan 2	9	98
Andy Snawerdt	IMU data collection, Model	5	97
David Wehr	IMU data collection, WiFi bridge work	10	88

Comments and Extended Discussion

Continuing to work on the quadcopter model, and beginning on the second version of our Project Plan, we have realized that if we want to meet our goals for the project that we decided to try to achieve by the end of this semester, we really need to finish the Simulink model as soon as possible. Because, without this model, we cannot begin testing our PID controller designs, so we cannot begin doing flight testing on the actual quadcopter system itself, which pushes back our progress on the autonomous flight deliverable goal overall. We are beginning to think that maybe we cannot get this

deliverable by the end of this semester, since we only have a few weeks left, and this step requires a lot of additional testing and additional tuning even after getting our original design for the PID and after doing tests with this on the Simulink model.

Plans for Coming Week

- Work on Project Plan Version 2 – All team members
    - Need to make some changes to our project plan, which align with the comments given to our project plan version 1 submission, as well as with what Dr. Jones mentioned he wanted to be different with this document
    - From the above sources, here is a compiled list of what we must incorporate as changes to the Project Plan document:
        - Include more images and diagrams (recommendation from Dr. Jones)
        - Add to our "References" page if possible (suggestion from evaluation comments)
        - Make references to the sources in our references page, throughout the document of the Project Plan (suggestion from evaluation comments)
        - Condense our "Deliverables" section to be more or less a bulleted list (suggestion from evaluation comments)
- Continue working on sensor block – Tara and Andy
    - Check with Matt about assumptions made off of our frequency domain representation of the noise, and our assumption that the negligible
    - Implement the calculations that is being done on the software side
        - Well represented in Brendan's data flow diagram
        - This is the part that occurs after the "IMU Sensor" block of the system, since this is something being done to the raw IMU data to calculate pitch, roll, and yaw of the quadcopter, as well as its angular velocities
- Continue working on pendulum project setup and documentation - Joe Bush
- Resolve data corruption with WiFi bridge and test sending VRPN data every frame - David, Kris
- Implement some quad functions on the ground station
    - Steps to implement
        - Implement the command between backend and quad
        - Implement the command in the frontend-backend protocol
        - Implement a function for the command in the front-end
        - Add args to the CLI/Getopt to handle the command
    - Will probably implement getIMU and monitor.
- Continue working on updating Quad-side communication packets - Eric
- Hardware upgrades - Eric
    - Verify that new ESC will work for controls team
    - Order LiPo charging sack, LiPo storage sacks, and new ESCs
    - Look into getting a fire extinguisher for the lab (for LiPo fires)

Summary of Weekly Advisor Meeting

This week we discussed some of the issues the communications sub-team was having to minimize the latency of the data. Since most of this was already discussed in an email, Dr. Jones and the team was fully informed of the details of this problem and the effect of some of the attempts to work around this problem, so after a brief summary at the meeting, Dr. Jones gave this team a "next-step" task to

try and send data at a faster rate, since this will likely decrease the latency. The controls team discussed their progress so far, and their plans for how to work on the next part of the Simulink model, which is the Sensor block. The ground station team discussed their updates to the command line interface (CLI) and its current state of being able to send camera system data to the quadcopter.

- Link to website on Wiki page has been added
- TCP status from David and Kris:
    - Have not done anything since the last email, where the issue with the TCP latency never getting smaller than 40 milliseconds was realized and described in detail
    - Have tried measuring the latency with both Kris's and and David's laptop
    - Possible solution recognized by Dr. Jones in email:
        - Don't wait for the "acknowledgement", which will take up to 40 milliseconds
        - Simply send data faster than the 40 milliseconds limit, without waiting for acknowledgement
        - Should decrease the latency, and will receive the ACK with a 1 cycle delay
- Controls team update:
    - Actuation block of the quadcopter model in Simulink is done
    - Next step is to begin the Sensor block of the Simulink quadcopter model
        - Part of this step includes representing the sensors themselves in Simulink
        - Should include the option to turn the "noise" portion on and off in our block
    - To characterize the sensors, need to work with the software sub-team
        - Will do a test with the quadcopter being stationary to see what kind of noise we are getting from the accelerometer and gyroscope even when the quadcopter is not moving
        - Matt Rich says we should take as much data as we can with this setup, since we need a lot of data to accurately represent the variation we are seeing with the noise from the sensors
        - Will analyze this data with MATLAB to characterize the noise as a white noise, with a normal distribution, with respect to a mean offset and standard deviation
- Command Line Interface (CLI) update:
    - This sub-team added a lot to the design document and discussed how they were going to implement the command line interface
    - We currently have the "backend" part of the command line interface, which can forward camera data to the quadcopter
    - Dr. Jones's recommendation for developing the User Interface:
        - Look at the GUI from the 2012 team for ideas
        - Has multiple panes and allows the user to draw their own examples
        - A very nice user interface, with good features
- Quadcopter Software sub-team updates from Joe
    - Mostly worked on the design document this week
    - Will get up-to-speed and on one page with Brendan in terms of the software diagram
- Our ideas for what timeframe we imagine for getting the quadcopter in the air
    - Controls sub-team ideas: with the Actuation and Communication blocks done for the Simulink model, and with the expectation of getting the Sensor block done within the

next week or so, we will then just have the Control block to do though we do not know how long it will take, but we can hopefully get this all accomplished before break
    - According to Dr. Jones: the control block should be easier to implement overall
- Important notes for spare parts:
    - We should get spare propellers and motors
    - Especially important to get these spare parts when we begin doing testing with flight
    - Important because may possibly crash a few times, even if we try to be careful and incremental in our testing, and we do not want to delay our progress because we are waiting for replacement parts
- Need to reproduce the old system (the quadcopter software in C) in Simulink
    - According to Dr. Elia: need to also check that it makes sense
    - We should certainly check that the results make sense
    - But on top of that, as we are writing it, we should check that logically each line/step makes sense as well
    - This “reproducing” process can introduce real problems when designing a controller for our system, so we should be very careful and systematic in this model development