60 Days to a Finished Thesis

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1 Introduction

This document outlines how I'm going to finish the bulk of the required research that is remaining for my thesis by the end of the summer. I attached a spreadsheet Gant Chart. The idea is that we're just revising the thesis by the time I have to take a job. This is kind of assuming I don't get a job at UNH, but even if I do get a job at UNH it will be good to have a solid plan to stick to. I propose that the thesis takes the following outline (listed by chapter).

1. **Introduction:** Talks about what's even in the thesis and some background stuff like why the problem is important, gives the outline of the thesis

2. **CelNav Attitude Mathematics:** Defines all the coordinates systems. Discusses the attitude matrices that rotate from inertial to camera body frame etc. Discusses the adjustment matrices for the refraction of light and the nutation of the earth. **Most importantly** discusses the difference between the UNH Gamma, the Texas A&M Gamma and the Hybrid Quaternion Gamma

3. **CelNav star tracker Mathematics:** This is the piece that was pretty much missing from previous UNH work. This chapter will talk about the centroiding algorithm, the star identification algorithm, method for translating that to a meaningful attitude.

4. **Observer Based Control:** Here I'll talk about the Theory behind the observer based controllers and also have the plots of the simulink for both unstable and stable pole locations. The other novel thing we're going to have is the mathematics that extracts the gravity vector from a rover that with nonzero acceleration.

5. **Experimental Setup:** Here I'll talk about two experimental setups that we have. The first is the NavSwarmBot for the testing of the OBC. The second is the CelNav camera that I'm making along with what components go with it. So far its just a tripod, tripod head for holding at a known angle, and an accelerometer. Picture below. The Camera tripod has gradations on it for holding the accelerometer and camera at a specific angle. Also, this kind of makes the X axis the Z axis of the literature but its a pretty clean way to mount the accelerometer.

Figure 1: Tripod Setup

6. **Experimental Results:** Here, I'll talk about the results we gathered. Like did the new Gamma method work. How did the controllers perform on an actual robot, and was the gravity vector extracted from the rover correctly.

7. **Conclusions and Future Work:** Wrap up the thesis and talk about whats next for the project, including the shortcomings of the project as well as what worked well.

8. **References and Appendices:** All the other stuff that didn't just fit in.

2 Descriptions of Each Item

Each task is shown below.

2.1 Experimental Verification of Gamma

This is the part of the attitude orientation where we're accounting for non zenith orientation requirements. This was kind of stalled because I wasn't able to hold the accelerometer at a consistent angle but we're good now.

1. Purchase Tripod with "Head": this is a tripod that can measure a consistent angle. I showed it in the earlier picture.
2. Calibrate IMU: The IMU doesn't start off being accurate but there is software so we can fix that.
3. Text data out of the accelerometer: to manipulate the data, it needs to be in a usable format going back into the computer.
4. Graphically piped into the Quaternion Scheme: Basically this means plotting the predicted angles vs. the actual orientation of the accelerometer. I kind of want this to be animated but it doesn't HAVE to be.

5. Range of angles established: Means we know the range of angles where the error in Swanzey's model due to the $(1 - sin^2(\psi) - sin^2(\zeta))^{1/2}$ term is an acceptable amount.

2.2 Camera Selection

1. Research different cameras: Basically I'm looking at using a DSLR camera in order to capture the images of hte stars. It's possible to get a decent image with a longer shutter exposure time, and a certain lens. If it seems feasible compared to a CCD camera I'm gonna go with the cheaper camera because basically what we need is a decent starfield to get the star id algorithm to work.
2. Purchase Camera: ez pz
3. Set Up Streaming Camera: Basically what I want this to do is take the picture, then be able to manipulate the image to do the algorithms and stuff. Then, I want it to be able to take another picture autonomously. I know a guy who can teach me to do this for DSLR. Not sure how it would work for CCD yet.

2.3 Image Processing

Basically dealing with the software that manipulates the image data. 1. Meet Will: Will Nitsch from the ECE dept is going to help me work on basic image processing and get me started with some of his code. 2. Take some starfield images of the night sky: Basically taking different pictures of a known part of the night sky in order to get the centroiding algorithm to work.
3. Write Centroiding Algorithm: Basically Will has solved this problem but Centroiding is the locating of the different stars within the image field.
4. Research Pyramid Algorithm: Pyramid is the algorithm that looks at the stars and ID's them as well as filters out "fake" stars that we had a problem with when we tried out the CCD camera in the White Mts.
5. Write Pyramid Algorithm: This means getting that research to work in the software. That's kind of why they occur at the same time.

2.4 Observer and Controller

1. Fix Gains on Simulink Models: I'm pretty sure that the gains here are wrong. So, I'm going to try to get functional gains in order to have a stable system, to avoid that cone shape in the plots.
2. Error Dynamics Analysis: Looks at $\frac{dE}{dt}, E = error$ to help come to conclusions about stability.

2.5 Acceleration Detection

CelNav in its current form works only if the system isn't moving. Since the end goal of this project is to have CelNav on a mobile system, we need a method for extracting the gravity vector, or the roll/pitch of the accelerometer (same thing really) out of the accelerometer with a non-zero acceleration. I gave myself all month of august pretty much to do all that piece because I'm not entirely sure what's involved. MY GUESS is that you somehow subtract the rover acceleration from the total measurement but I'm not sure how you isolate one from the other. It's definitely possible and I've seen titles to articles that claim they do this. There's a way and that's what's important.

3 Budget/Misc

I'm hoping to be able to rebuild the whole thing for less than $500. So far the tripod w/ head was $50 and the Razor 9DOF IMU was $75. This leaves about $375 to buy the camera, and then doing all the programming on my computer (another big reason I'm leaning DSLR... I can definitely afford it). I'm just gonna assume since it was built last year it's gonna be strong enough, although the Draper version of this project had some serious stuff going on.