Progress Report

ARC - Autonomous RC

Senior Capstone Project

Oregon State University

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1 Project purpose and goals

The purpose of the Autonomous RC (ARC) project is to determine if it is possible to build an autonomous RC vehicle using commodity components, meaning components that are relatively inexpensive and can be bought at places like Radio Shack®, Best Buy®, or on Amazon.
Our goal is to make an RC vehicle navigate autonomous to a given waypoint/location, preferably at a high rate of speed. Stretch goals are to make the vehicle drift around corners and parallel park.

$Besuretoaddgraphicbackinbeforefinalrender$!!

Fig. 1. Drifting example. Image from https://autorally.github.io/

While our main goal is to have a functioning autonomous RC vehicle we also hope that we can produce instructions that RC enthusiasts can follow to produce a functioning, consumer-grade autonomous RC vehicle of their own.

2 Current Status

Currently, we have finished our project proposal, SRS, tech review, and the preliminary version of our design document. Our design document is a week behind where we would like to be, as it was difficult to complete the SRS document without having first done the tech review. This significantly impeded our progress, as we were scrambling to finish the SRS after we had finished the tech review, and then our design document was due a few days later. There was definitely a large wall we had to climb without hand holds in terms of knowledge that this project required.

The first step in implementation will be testing if the hardware we have, works with the software we would like to use. The design document talked about how the system communicated, and what milestones we wanted to be able to meet at a basic level. Once these preliminary milestones are met, we can advance the design document to reflect the requirements we are trying to meet.

Now that we have a better idea of how the system fits together, we plan over break to work on the first steps of the milestones proposed in the design document. This will be the first point where we see if what we have can function in the way we are hoping, or if we need to modify which hardware we are using to accomplish the goal. One big piece of

this will be seeing if we can process vision data fast enough for our needs, to ensure that our goal is even possible. We have no plans of testing with the car until we are sure that all of our hardware is talking properly. Ideally by the end of break we will be ready to either modify our design, or start retrofitting the hardware onto the vehicle.

3 WEEK-BY-WEEK SUMMARY OF ACTIVITIES

One thing to note about the following weekly activity summary: if some of our descriptions seem a bit vague, that is because our understanding of this project is still fairly vague. We are discovering what we need for this project to succeed as we go. As the project progresses our focus will narrow and details will become more concrete. Right now, our understanding of the project is still very abstract, therefore the concepts and details that we describe are also vague and somewhat abstract.

3.1 Weeks 1 - 2

Weeks one and two were general introduction and orientation weeks. It was not until week 3 that projects started in earnest and the first assignment was assigned.

3.2 Week 3

- *Activities*:
  Worked on creating the problem statement. This required getting an overall understanding of what our autonomous RC vehicle should be able to do. In other words, getting on paper the expectations of our client for the final product. We also started researching what we would need for the SRS document, both in terms of the ARC project and in terms of the LaTeX document. We needed a Gantt chart for the SRS, so we started researching how to do that.
- *Problems*:
  Our client was ill during this time, so feedback for the problem statement was understandably delayed. We struggled a little with using the proper tense in the document and getting a high-enough, yet detailed enough written view of the ARC project. We needed clarification on details for the expected vehicle capabilities.
- *Solutions*:
  We talked with our client on how to frame our project appropriately. For the vehicle capabilities, our client told us to aim high, if we need to scale things back later we will.

3.3 Week 4

- *Activities*:
  Received feedback on our problem statement and made required changes. We needed to clarify what our motivation for the project was, namely that we are trying to create an autonomous RC system that is considerably less expensive than current research platforms (think $1-2k vs $10-15k). Created a template for the SRS document and started looking into what requirements our project needed.
- *Problems*:
  The three of us on the ARC team have no prior experience with ECE, in general and Autonomy or RC vehicles, in

particular. This lack of experience makes writing these beginning documents somewhat abstract because we do not know what is involved.

- *Solutions*:

  We spent time with our client to talk through some of the requirements. Clarifying why this project matters also helped us narrow the scope of our requirements a little bit. We could focus on low-cost, readily available components. While that still leaves quite a bit to discover, it also eliminates expensive, yet otherwise viable, options.

3.4 Week 5

- *Activities*:

  Worked on the SRS document. This phase of the project required us to brainstorm what components our system needed and how they fit together.

  For instance, system interfaces has many parts so we had to sit down and talk through what connects and talks to what and visualize how that looks. For the SRS, filled out the introduction, software interfaces, communications interfaces, and the overall layout of the general control flow.

  Researched how to construct a Gantt chart in LaTeX. We also decided on what parts we each would take responsibility for and write about in the tech review document.

- *Problems*:

  The SRS document needed different indexing (numeric, as opposed to Roman numeral). This required some effort to figure out how to reformat the document to use a different indexing scheme without changing the controlling document class.

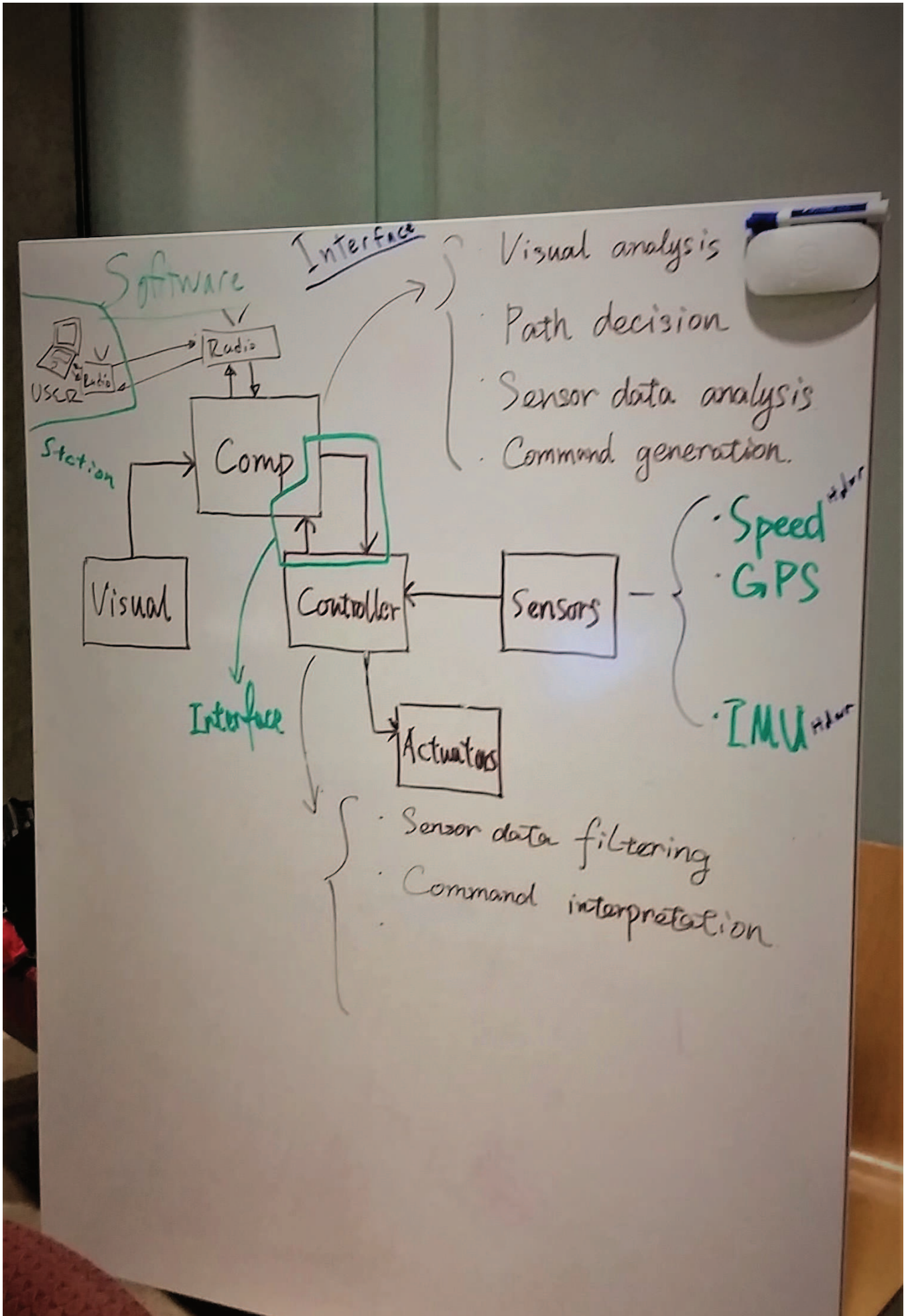
  Other problems: The nature of our project is complex. Therefore, there are many parts to the requirements for this project. We needed to estimate what the project would need, but again, without experience.

  Researching and building a working Gantt chart in LaTeX took about 9 hours. The system is very cumbersome, which makes one not want to revisit it to make changes.

- *Solutions*:

  Fixed the LaTeX index formatting issue by adding an argument to the IEEEtran.cls options. This turned out to be a pretty easy fix, but took quite a while to figure out.

  We tackled the complexity of this project by meeting together and drawing out a rough sketch of major components and how they relate to each other.


Software
Interface
Visual analysis
Path decision
Sensor data analysis
Command generation
Radio
User
Radio
Station
Comp
Visual
Controller
Sensors
Speed
GPS
IMU
Interface
Actuators
Sensor data filtering
Command interpretation

This gave us a starting point to work from and fill out details for what will be required in this project. A big caveat is that these are still an *estimate* of requirements. We won't really know where we are correct or where we need to add until we get hands-on with the hardware and software.

Somewhat mitigated the arduous nature of the LaTeX Gantt chart by creating a sort of auto-calculation of the percentages for the different tasks and sub-tasks.

3.5 Week 6

- *Activities*:

  This was a *very* research-heavy week. We did in-depth research on our main areas of emphasis: system interfaces, user interfaces, hardware interfaces, communications interfaces, sensors, navigation, hardware mounting (how to physically attach the components to the vehicle), system control and data processing, and path planning. We created a block diagram of the structure and data flow of the project.

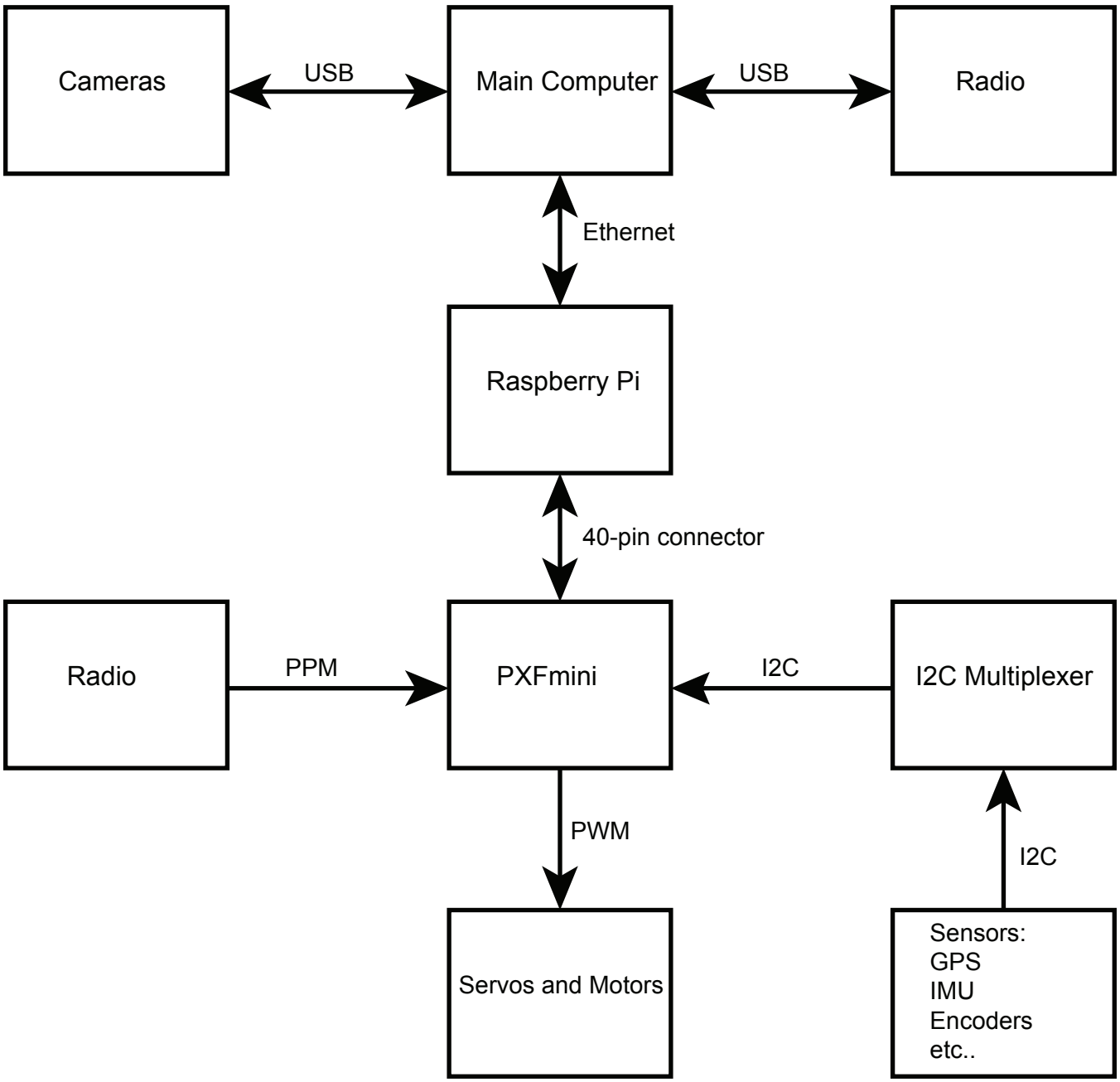


Fig. 3. Structure and data flow of the ARC project

We worked simultaneously on the tech review and SRS documents. This is likely going to be a better strategy moving forward, research some area of the project, determine a requirement based off of the research, try to implement, record our findings and adjust the requirements further if necessary.

- *Problems*:
  Which came first, the chicken or the egg? This is how it feels to be writing the documents for this research project. In order to know what requirements are reasonable/feasible, we need to know what tech is out there and if/how it fits with related components.
- *Solutions*:

To get around some of the issues we are having we decided to write the SRS and the tech review somewhat concurrently. This allowed us to research our areas of the tech review and then have a better understanding of what a reasonable requirement might be for the project.

3.6 Week 7

- *Activities*:

  This week was very similar to week 6, as we continued to research more about our topics and headway on the SRS. We managed to finish the introduction of the document and we described the general interfaces between components, even though we were unsure of what components were going to be used. Here is a list of some of the components that were researched and their results:

  - Image analysis software

    Found DroneKit-Python, ArduPilot, and LibrePilot.
  - Telemetry radios

    Found 3DR 915 MHz Transceiver, RFD900 Radio Modem, and OpenPilot OPLink Mini Ground and Air Station 433 MHz
  - User interfaces

    Found QGroundControl, DroneKit-Android, and LibrePilot
  - Vision System

    Found stereo vision camera implementations, different methods for parsing stereo vision, and the benefits and challenges of LiDAR
  - System Interfaces

    Found hardware specifications for Intel NUC, UPBoard, and Raspberry Pi 3, along with documentation on the PXFmini
  - Sensors

    Found data specifications for GPS, IMU options, and PXFmini's onboard sensors
- *Problems*:

  The biggest problem we had this week were sifting through hardware documentation, that was well... lacking in the documentation aspect. The SRS document was also conceptually difficult without having an understanding of the technology behind it, which made it feel as if in order to finish the SRS, namely the requirements section, we would need to do the tech-review first to have a better understanding of what the realistic capabilities of the technology Another problem was trying to make progress on the SRS document without having completed the tech review first.
- *Solutions*:

  We spent more of our time researching to gain a better understanding of what we would need to do. When we found technology that seemed promising, we would add it as a component to our tech review. Stepping back to look at the broader picture also helped us be able to fill out a good portion of the first half of the document.

3.7 Week 8

- *Activities*:

  This week was focused on more research, primarily for the tech review. Thursday was also thanksgiving break, so not a lot happened between Wednesday and Sunday.
- *Problems*:

  The biggest problem was sifting through a lot of research that doesn't have any examples to look at.
- *Solutions*:

  Found as many basic examples as possible.

3.8 Week 9

- *Activities*:

  This week we managed to finish our tech review and started making progress on filling out our SRS document. We would call this the "AHA!" week in terms of progress, as we finally started to see how our project was going to come together. After turning in the tech review, we were able to start filling out requirements, which was significantly easier after knowing what the realistic capabilities of our hardware.
- *Problems*:

  The biggest problem was being a week behind where we would have liked to be. Our SRS document was still not completed, even though we are making a lot of progress.
- *Solutions*:

  Our solution was to keep on moving forward and trying not to be affected too much by the setback from the previous documents. The next step was finishing our SRS document so that progress could be made on the design document.

3.9 Week 10

- *Activities*:

  We finished our SRS document, and received Kevin's seal of approval. The feedback we received was positive, which was surprising and satisfying at the same time. We finished the design document, which created as a preliminary design, to say what the layout and communication methods would be, along with with generally what software we would be using, and what milestones we would need to hit in order to test the viability of our solution.
- *Problems*:

  The biggest problem comes back to being a week behind and needing to finish the design document. As a research project, the design document specifications from the IEEE format didn't follow what we needed, so we ended up having to talk more about our process and general design, rather than specifics, since they are still unknown.
- *Solutions*:

  We managed to finish the design document by just putting in as much time as needed, however, it wasn't quite to the level that we would have liked. This means we will continue to develop the document to better meet the specifications, once we have tested our system viability. If the system is not viable, we will revisit the design and see what needs to be done in order to succeed.

4 RETROSPECTIVE

Positives: Anything good that happened.	**Deltas:** Changes that need to be implemented.	**Actions:** Specific actions to resolve deltas.
	Design document needs more implementation detail	Winter term add implementation detail.
Defined our goals for the project		
	We needed to have more more regular meeting times	Each week we will schedule time to meet, and treat as if it is part of the class.
	Work needs to be done earlier	By meeting on a regular basis, we should be able to start and finish our assignments before the deadlines.
	More detail can be added to the weekly summaries, to better document what has happened. Due to the nature of this term being mostly research, we were unable to include a lot of detail of what has happened.	We will make a better effort to include more of the details process of what we went through. This can be done by making daily notes of what we've completed when starting to implement features.
Learned a lot about reading technical documentation and sifting through research in order to determine what components would work for the project.		
We've gained a more complete understanding of the dynamics and components of our project, and what goes into making a vehicle autonomous		
	Due to the research nature of the project, we're not really sure what our delta's are, as a lot of them will be found as the project progresses	One we have a better understanding of things we've encountered
Communication has been strong throughout the group. Using hangouts and meeting in person, we're typically on the same page about what needs to be done and by whom.		