Diego Torres, Samantha, Savis, Suri
Advisor : Smedley

ABET Midterm

3) An ability to communicate effectively with a range of audiences. This ABET criteria will be evaluated via your in-class presentations, posters, videos, etc.(It's listed here just so you know that it is important and specifically evaluated per ABET's requirements).

Throughout this senior design project there are many skills that we had to learn quickly. Whether those be technical skills, time management skills, and the most important skill of all was the communication skill. Developing a good foundation of communication skills with a range of audiences is essential among the team members to convey the project at hand to all backgrounds of people. Being an engineer means that you are able to do all the work at hand as well as provide an effective explanation to others too. Thus, the communication skill was developed to address all ranges of people through a wide range of practices.

To name a few, as a team we presented in- class presentation to our engineering peers. In this environment we were able to convey our technical terminology and findings from the project in a point of view that we all can understand. A poster presentation was also conducted which allowed all faculty members, our peers, and other non engineering majors to observe and as questions about our poster and the project underdevelopment. With the poster presentation this allowed for an adjustment in communication depending on who we were addressing. Each person that we spoke to we had to understand what their background was and speak to them in a manner that was not too general but at the same time not too complex. Another communication media developed was through videos. In these videos, it allowed the teams to showcase the progress of the projects in an environment most optimal for the project to run under. The videos also allowed us to redirect the terminology usage to our audience. We need to express more of a technical vocabulary to describe what is occuring in the video, whether that be the assembly, the interface between two systems, or how robot functions. Overall there has been a range of communication skills learned and delivered to a range of audiences both in the classroom and outside.

5) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Overall our senior design group was able to manage external activities such as work, school and our project. This balancing act of figuring out when other members are free and trying to create time slots where we all can meet and work on the project was not easy, but we all managed to set a time system that worked for us all. This team worked together well, the reason being because we all are motivated to develop and create a functioning project.

The way we organized work in this team was dividing each element into two major parts and worked in parallel with one another. This would allow for each team to research, develop and test their components but then we would have a general meeting discussing how all these elements come together in the overall picture. This allows for each member to be included and apart of each task to have an input or comment on the overall progress. Even though along the way it was very difficult to have all the pieces of the project coincide we did need to create several other meetings in order to ensure that this project will be feasible. In the end we needed to change the scope of the project a little to address the issues faced.

At each team meeting our team captain would address important questions that most of us did not think of and we all would add our input as well. Time management skill was a very important factor for this project as well as among the team members. When we would work together we needed to be efficient and not waste time when we met together. Thus, as a team we all shared times that we were available and correlated when each person can meet together. This was all formed using a professional platform so members can communicate called Slack.

6.1) An ability to develop and conduct appropriate experimentation.

In the beginning, per our mentor's advice, we tried to implement our own P/PID controllers. We researched extensively how to build those controllers on our own for the error signal (the difference between goal speed and measured speed), Once we were introduced to PWM signals we realized we can control the amount of voltage outputted to our DC motors. We also realized that, we can use the raspberry pi to code the P/PID controller. Therefore, we did not need capacitors or resistors to implement the controller as the raspberry pi as a computer can handle this arithmetic; however, during this period, we ended up creating our own PID controller. We developed the PID controller based on the information we found in the Feedback control of dynamic systems textbook. Through this exercise, we were able to do what the raspberry pi is capable of doing on its own but we learned that in case we do not have access to a raspberry pi or we have a simple microprocessor, we can still design our own pi controllers and op amps to compare the speed signals. We also faced some difficulties with the model car that we had purchased as the h bridge included in that car was not able to communicate properly with our raspberry pi. We, therefore, used a simpler h bridge and assembled our own car. We learned that sometimes complicated kits can be harder to debug and so it may be easier to create our own simpler cars and kits.

6.2) An ability to analyze and interpret data, and use engineering judgment to draw conclusions.

The data that we have collected involves timing and efficiencies of certain algorithmic approaches as well as performances for the machine vision portion measured in terms of accuracy. The top down approach to writing more efficient code is to first write so that it functionally works with no regard for speed, then refine the code so that it may meet your timing needs. The timing of the project can be divided into 3 major sections: video stream delay, image process delay, and the command transmission delay. The video stream delay is defined as the time it takes for an image to be shown in front of the pi camera module until it displays on the base computer station. The image process delay is the amount of time it takes for the image once it is shown on the screen to be processed and displayed with the correct bounding boxes and the correct output information for the detected object. This type of measurement can be commonly seen as the fps of the image being displayed. The command transmission delay is the amount of time that it takes to utilize the results from processed image to return a command back to the raspberry pi and execute the command.

The video stream delay can be observed as the latency between what is occuring in the physical world and its image representation seen on the computer. Ideally there should be a latency of 170 ms, which is the average response delay of a human for a given visual stimulus. The delay of the video stream server is far greater than 170 ms. To measure the delay we flashed a light into the camera, and at the same time we pressed a stopwatch on our phones. When we saw the image on the computer we stopped timing it. We took the average of the 3 project member's times. Below is a table showing the $video_{delay}$ measurements.

$video_{delay} = avg\_measured_{delay} - [2 * (170ms)]$

Measurement #	Time (seconds)
1	1.02
2	0.78
3	0.95

Figure 1.

The results show that the average $video_{delay}$ is 0.58 seconds. However these results do not account for changes in the internet. A congested network can have serious impacts and the retransmission of the the video packets. Therefore the video delay is subject to severe variability. A range is a better representation of the delay, (0.70,2.00) seconds. The image process delay was measured using the time library in Python. It was measured from the line of code directly after the image was loaded onto an opencv image object to the time that the results were printed onto the screen. The times were consistent and varied by only a few ms. Below is a table of the $image\_process_{delay}$. The measurement number corresponds to the next frame in video stream.

$image\ \_process_{delay} = avg\_measured_{delay} - [2 * (170ms)]$

Measurement #	Time (seconds)
1	.039
2	.025
3	.038
4	.036

Figure 2.

The average $image\_process_{delay}$ = 0.0345 sec. The $image\_process_{delay}$ is small compared to the $video_{delay}$. This effectively shows that transferring the image processing load to a separate, more powerful computer had significant advantages. The command transmission delay, is the time measured after the output is seen and when an LED on the board is triggered. The same technique that was used to measure the $video_{delay}$ was used. Below is the table showing the measurements

Measurement #	Time (seconds)
1	0.12
2	0.09
3	0.14

Figure 3.

The average of the $command\_transmission_{delay}$ = 0.116 sec. The average delays totaled 0.73 sec. This value represents the total time it takes for the entire system to package and send an image, process it, and then relay the corresponding commands back to the rpi.

The accuracy of the image processing is the amount of times that the system can correctly classify the intended traffic road sign. There were a total of 10 trials. At each trial the traffic road sign was shown 1.5 feet from the camera module using pictures on our smartphones. The accuracy is just the mean of the correct classifications over the total number of trials. Below is the table describing the accuracy.

Trial #	Red traffic light	Green traffic light	Yellow traffic light	Stop sign
1	x	x	x	x
2	x	x	x	x
3	x			x
4		x	x	x
5	x		x	
6	x		x	x
7	x	x	x	x
8	x	x	x	x
9	x	x	x	x
10		x	x	x

Figure 4.

The accuracy shows that it performs well; the red light, green light, yellow light, and stop sign have accuracies 80%, 70%, 90%, 90% respectively. The accuracies have small correspondence to the accuracy that will be seen in the real world given that there are many environmental factors that contribute to difficulties in machine vision like lighting, occlusion, textural differences, proximity, and observable detail.

The majority of the delay is attributed to the video stream. While the video stream grants us the ability to more efficiently process the information it does not allow for an effective way to transfer and relay information back to the car because of the slow transfer rates. While the video stream is sufficient for everyday use in watching videos, listening to music, podcasts etc, it becomes hard to place the video stream as a comfortable solution to the problem of having an onboard computer utility capable of processing the image information. If given enough time, then a more optimal means of video transfer speeds could be obtained but for now the current usage is suboptimal in practical means. The delay is the limiting component however the strength of the offboard image processing is strong enough to make for a demonstrable system.The accuracy of the image processing system shows that it is capable of recognizing the images that it was trained for. However as stated before there are many environmental factors that limit the usage of haar cascades in autonomous vehicles. These NN systems prove to have a higher accuracy in different environmental settings. However our image recognition system is extremely valuable in that highlights some of the major problems that are ongoing with the state of the art systems, training a system good enough to solve a problem it wasn't intentionally designed to solve.