Computing Technology in Society
(CArduino) Report

Self-Driving Cars

The comparison of our prototype and real self-driving cars.

This report was compiled for AUT Computing Technology in Society. It investigates the purpose of self-driving cars and the comparison of self-driving cars with our experiment. This report was requested on March 7th, 2019 and is due on 31st May, 2019.

Azimah Ali
Leon Yang
Roshan Mistry

Word Count: 3209

Abstract

This report will aim to discuss the emergence of self-driving cars around the world and will investigate the statistics behind car casualties caused by manual cars and compare it to casualties caused by self-driving cars. This report also aims to investigate whether self-driving cars are safe or not and the views people have about it. Tesla's CEO Elon Musk has been vocal about the development on self-driving cars and acknowledged the many concerns people have. As a team, we decided to replicate a practical prototype of a self-driving car to demonstrate and become aware of the safety precautions, pros and cons of a self-driving car. Furthermore, this report provides reasons as to how our prototype works as a self-driving car; limitations; and general suggestions on how we could have made further improvements.

Acknowledgment – Carduino. Azimah (17982007), Leon (18044265), Joao (18026848), and Roshan (18029259).

In understanding the project, Azimah researched into autonomous vehicles and collected and shared the materials she already owned from the Arduino kit. Azimah served as the group leader and taught the rest of the group how to use Arduino and how to write and upload code as well as guiding us on how to build the initial prototypes. Leon did the background research on why we are building an autonomous car and helped in constructing the prototype. He researched the past instances of crashes in New Zealand and the causes behind them. Roshan and Joao oversaw the wiring of the car and creating our very first prototypes. They wired the distance sensor and followed the instructions of our group leader Azimah. In preparing the project we all did equal amounts of work. Azimah was still teaching the rest of the group how to create the autonomous car. She uploaded the code to the car after the rest of the group was done constructing the car. However, during this stage after the third week into the semester our fourth member Joao had dropped out of university and left our group so there was only three of us in the group. This did not phase us as we slightly shifted roles within our group and adapted to this change. Azimah assumed her role as the group leader and took upon the tasks of helping create the meeting minutes. As Roshan and Joao roles were practically the same, there were no issues in Roshan continuing with constructing and prototyping. He had the help from Leon. We feel as though all members in the group have contributed equally, if anything Azimah has done more work than Leon and Roshan. As she was the group leader and taught us to use Arduino as we were complete novices. However, we feel as though Joao has not contributed to this group project. At the beginning he showed up to meetings and classes on time but then he decided to drop out of university, but he was still listed as one of our group members. Joao only helped with wiring the distance sensor before he dropped out and the rest of the group was left to build the prototype and the final autonomous car.

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1.0 Introduction

1.1 Purpose

The purpose of this report is to replicate a self-driving car and investigate the reasons behind why an autonomous driving vehicle is safer than a remotely or manually controlled vehicle. The report will recommend preventative measures for the growing death toll on the roads in New Zealand. This report will also investigate the factors influencing the growing use and drive to build autonomous driving vehicles and suggests ways to promote positive impact of autonomous vehicles on the number of crashes occurring on the roads in New Zealand. The purpose of this report is also to demonstrate how an autonomous vehicle operates and the components needed for it to run.

1.2 Background

Self-driving cars can automatically transport its passengers from one destination to another with little to no interaction with the driving wheel. Before Tesla and Google were invented, back in the 1920s and 1930s there were driverless cars known as Phantom Auto (Adrienne LaFrance, 2016). The car was not computer controlled like Tesla or Google. These phantom cars were remote-controlled (RC). The car had no human drivers; however, they weren't exactly self-driving due to them being remotely controlled by a human driver. Tesla and Google cars are currently the most known types of self-driving cars. Tesla was founded in 2003 by a group of engineers and was officially launched in 2008 (Tesla, 2019). While Google car was first founded in 2009. Tesla was invented to prove to people that they do not need to compromise to drive electric. While Google car, they wanted to test self-driving cars and see what the limit was. Self-driving cars are becoming much more popular nowadays, due to efficiency. 94% of car accidents are caused by reckless drivers, and as of last year 388 deaths in New Zealand was caused by these kinds of drivers. Automatic driving can reduce the amounts of casualties caused by reckless drivers. Self-driving cars has many components compared to manual car. The cars consist of cameras, radar sensor, main computer, and lidar unit aka 3D laser scanner. We can compare these to what we have used for our project, we used a distance sensor which is quite like a radar sensor. This is because they both function the same way where they both detect nearby objects and then an action is performed. Next the main computer can be compared to our circuit board that we used, since this is where all the coding for the car is installed which is the same as ours.

1.3 Scope

For our investigation, we needed to know what type of sensors to apply in order to replicate a self-driving car. We investigated the number of casualties caused by both manual and electronic cars to compare the pieces of data.

We also needed to understand the context behind people having an issue with self-driving cars. Generally, people believe that a self-driving will reduce car accidents. However, in California as of March 2018, the Tesla Model X car on autopilot mode crashed, causing the death of one engineer. This issue raised questions about the safety of this technology. Elon Musk defended self-driving cars by stating that 40,000 people have been killed by crashes in a year and get no coverage, whereas one casualty from the Tesla crash gets more coverage.

The pros of self-driving cars are they can be self-driven, reduce accidents caused by human error and they will not be caught in traffic. The cons for them are, main computer can malfunction, expensive to purchase and vulnerability to hackers.

2.0 Method of investigation

For our investigation, we collected primary data from the internet and used Arduino from SparkFun for experimentation, I.e. prototyping, iterating, testing/trialing.

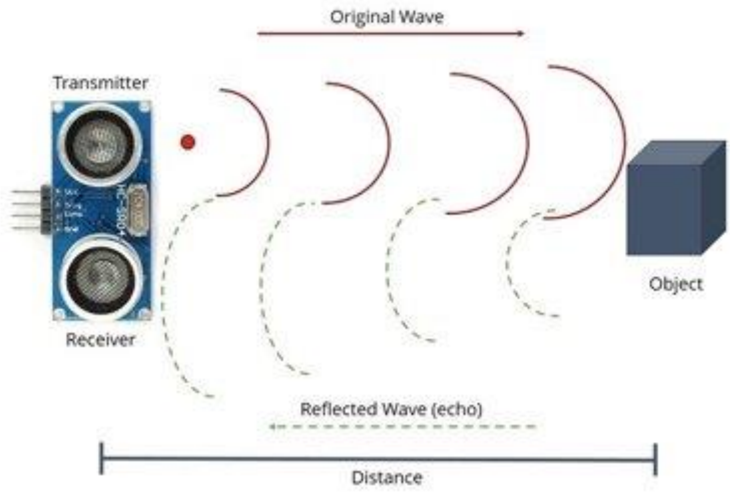
3.0 Findings

Test	Outcome	Issues	Fixed	Next steps
RGB light	• Distance sensor works. • RGB light changes depending on the distance of the object. • **RED** when object is closer. • **ORANGE**/YELLOW when object is near. • **GREEN** when object is distant.	• RBG light not working – wrong way. • Code wasn't complying. • Broken wire from the gear motor. • Wheel was stuck in the gear motor.	• Flipped it so that the cathode and anode were the right way. • Upload board and USB port to the Arduino software. • Soldering iron to fix the broken wire on the gear motor. • Plyers to remove wheel from the gear motor.	• Distance sensor – used for autonomous car.
Buttons	• Motor driver worked. • Gear motors worked.	• Wasn't working – motor driver was upside down.	• Turned the motor driver the right way.	Gear motors – needed for both cars. Motor driver – needed to control the car.
2-wheel drive	• Serial monitor commands the direction of 2 motors.	• Broken wires • Wheel got stuck in motor • placements	• Soldering iron and tape • Plyers • Taping boards into place	
4-wheel drive	• Serial monitor commands the direction of 4 motors.	• Placement • Wires not long enough • Wires breaking	• Double-side taping battery sources upside-down on acrylic sheet. • Replacing wires and soldering them on.	
Autonomous car	• Car moves on own accord. • Moves back to avoid objects. • Turns right and then continues moving.	• Gear motors places the wrong war. • Wires not long enough. • Wires bending. • Placement.	• Changing the sides of the gear motors. • Replacing the wires with longer wires and soldering it. • Replacing the bended wires with new wires. • Double-side taping battery sources upside-down.	

Figure 1.0: Findings Table

3.1 Testing Components

3.1.1 Distance Sensor



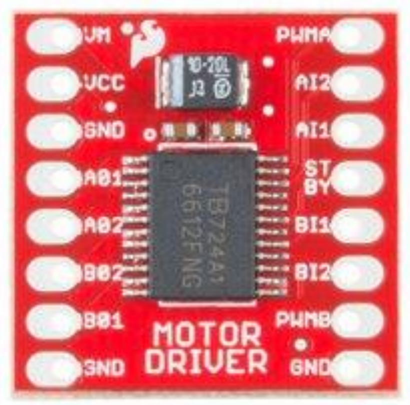
'Complete Guide for Ultrasonic Sensor HC-SR04 with Arduino.' Retrieved 22 May 2019. *https://randomnerdtutorials.com/complete-guide-for-ultrasonic-sensor-hc-sr04/*

To allow the autonomous car to be aware of its surrounding while it is driving around, we used a distance sensor. The distance sensor we used was the HC-SR04 ultrasonic distance sensor which was made by SparkFun. The sensor has only 4 pins: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground) making it easy to set up. It has an operating voltage of 5V and an operating current of 15mA. The distance sensor has a Transmitter pin and the Receiver pin. It works by the Transmitter pin sending out a high frequency sound and the signal is then reflected off an object and the reflected wave is then received by the receiver pin. The time it takes for the transmitted wave to return allows the sensor to determine how far it is from an object. This is possible because we know the velocity of sound in air. The sensor has a range from 2 cm to 4m. The code sets the if-statement so that if the distance the object in front of the sensor is less than 10 centimeters then the RGB LED light will show red. Else-if the distance to the object was less than 20cm but greater than 10cm, the RGB LED light will show yellow. Else-if the distance of the object was greater than 20 cm, the LED will show green. Although the distance sensor worked, the sensor did not initially work, hence the light didn’t work and the code that used was not complying. To combat the issue, we had to flip the RGB light around as we had the cathode and anode in the wrong way, and it worked. To fix the error we were encountering with the code not complying we had to upload the board and the USB port to the Arduino IDE that way the code will comply.

3.1.2 Gear motors

DC gear motors are motors that are coupled with a gearbox and transmission. This adds the mechanic to alter speed of the motors which is perfect for our experiment. The function of DC gear motors is to spin the wheel. We tested the gears motors with the button test to see if it worked. Each button controls each motor. Gear motor were also used in all car tests. We needed to have 4 DC gear motors for our whole car. The reason why we chose to use DC gear motors is because they are like how real car wheels operate, since we can adjust the speed of the motors.

3.1.3 Motor Driver



SparkFun Motor Driver - Dual TB6612FNG (1A). (2018). Retrieved 21 May, 2019 from https://www.sparkfun.com/products/14451

Dual H Bridge L298N Motor Driver Module | Lazada PH. (2018, October 9). Retrieved 21 May, 2019 from https://www.lazada.com.ph/products/dual-h-bridge-l298n-motor-driver-module-i103533146-s103952166.html

In order to control the gear motors for the prototype car, a motor driver; also known as a motor controller was needed. Two motor controllers were used for prototyping; TB6612FNG and the L298N dual H-bridge. Both motor drivers are functioned to do the same thing. For example, both motor drivers control the direction of motors over a set of switches called an H-Bridge. The motor driver takes commands over three wires; two of which control and one controls the speed. The motor driver then uses these signals to transmit current through the two wires attached to the motor. IN1 and IN2 are the two input signals that control the direction of the motor, for example it controls whether the motor drives clockwise, anti-clockwise or stops. PWM (pulse width modulation) input signal controls the speed of the motor with a frequency up to 100kHz. Each motor is controlled separately, hence each motor has their own set of input wires, i.e. IN1, IN2 and

PWM. Thus, as shown in the Button Test, the two motors were controlled separately by two different input signals and PWM signals, hence the two wheels are shown to have different speeds; right wheel is moving faster than the left wheel. Motor drivers also have a supply voltage (VCC) and a standby (STBY) pin set high to allow the motor out of standby mode. For the button test, the TB6612FNG motor driver was used to control the motors. Although, the button test worked, the TB6612FNG motor driver can only hold up to two motors, whereas the L298N can hold up to four motors. Since, we will be dealing with four motors we decided to use the L298N for prototyping further. There were other issues from the button test such as the code not compiling on the Arduino board. This was because the motor driver was upside-down. Hence, this issue was easily fixed.

3.2 Car Tests

3.2.1 Two-Wheel RC Drive

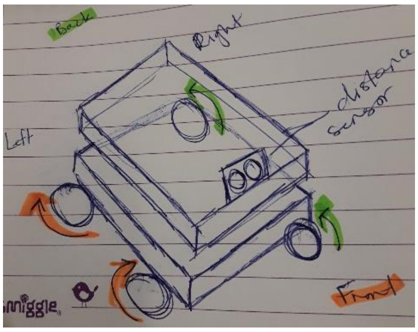
For construction of the 2-wheel drive for the car, we first discussed the code of the car using Arduino, we would use the serial monitor to send commands through the board to operate the car. The commands that we input are for the distance and direction, this determines how the car moves. The commands that are used for the directions are ‘f’ for forward while ‘b’ for backwards. During this time, we had to conduct tests to see if the 2-wheel drive for the car was working. The car was first built by installing the motors onto the car board, this step was quite easy. Once the motors are installed, the wheels are then connected onto the motors, to make sure the wheels worked firstly, tested if the wheels would spin manually. Once they worked fine, the next step was proceeding to wire up the motors to the circuit board. Each wire was colour coded to make it easier to understand. The right motors were put into pin 13,12 and 11 of the circuit board, pin 11 was determines the speed of the right wheel. The left motor was put into pin 10,9 and 8. Pin 8 was also the speed control but for the left motor. Next was putting a switch into the board, we used pin 7 for it. The code was then uploaded into the board. When the switch is turned on the wheels starts moving. The test we conducted can be compared to how car wheels in real life are tested. Car wheels are tested manually using a machine which determines the car works fine. While conducting the test for our car, we encountered issues. There were broken wires, wheel broke and placement of boards. The first issue where the wire was broken, we used a soldering kit to fix the wires. The next issue where the wheel broke, we had to use plyers to pull the wheel out from the joint. The last issue where the placement of boards was an issue, we had to shift around all the other stuff such as wires and motors.

3.2.2 Four-Wheel RC Drive

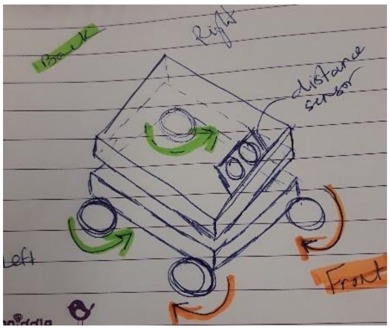
For the construction of the 4-wheel drive not many changes were made. As we had already decided to use the L298N motor driver, all we had to do was add 2 extra gear motors onto our prototype, wire it up to the motor driver and compile the same code from the 2-wheel drive. The 4-wheel drive car worked the same as the 2-wheel drive car as we were still using the serial monitor to send instructions through the board to control the car. The instructions used were the same. As all we had to do was use ‘f’ for the car to drive forward and used ‘b’ for the car to move backward. One of the major problems we encountered in this stage was finding enough space to place the 2 extra wheels as well as the gear motors and still have enough wire length for it to be able to connect to the motor driver. Our major issue was the placement of the components on the acrylic sheets as the wires we were using weren't very long so our components such as the motor driver and gear motors needed to be in a close vicinity to each other. To fix this we decided to use double sided tape and be able to tape some components upside down on the acrylic so that way we are able to utilize all the space on the sheets and not have the problem of some components and boards not being able to reach each other. Also, because of the fact we were often stretching the wires to reach to other components we faced the problem of constantly breaking wires to fix this we had to use a soldering kit to re-solder a lot of the wires back.

3.2.3 Autonomous Car

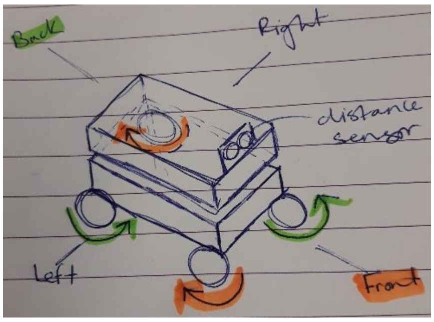
The autonomous car is like the RC car, in terms of the wiring and code. The difference, however, is implementing in the distance sensor through wiring it and adding the <New.Ping> feature in the code. The prototype car also does not need a serial port; hence the car moves freely with serial commands/communication. The function of the autonomous car is for the robot to sense an object with the distance sensor and avoid the obstacles. The prototype car is turned on by the switch, instead of a button due to button states; meaning it’s difficult for the button to have two states; on and off. The prototype will drive forwards on its own accord until an object is place in front of the distance sensor. When it senses an object, the car will drive backwards (reverse) to avoid the object and then turn right and continue its path. There were many issues while testing this prototype and many iterations to fix the negative results. The main issue was the arrangement of the gear motors. The gear motors were placed the wrong way in majority of the tests; leading to wheels spinning in opposite directions.



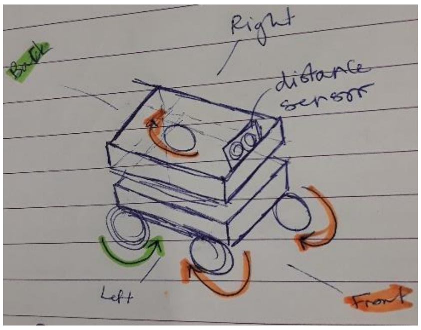
Test 1



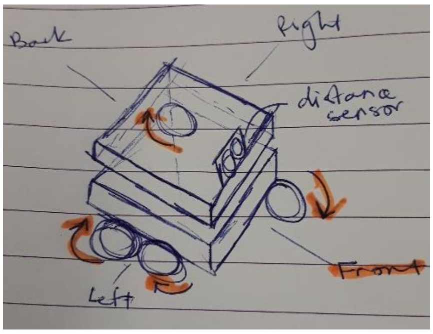
Test 2



Test 3



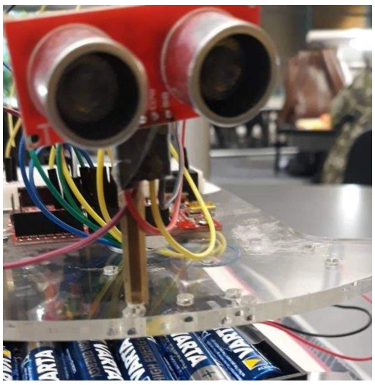
Test 4



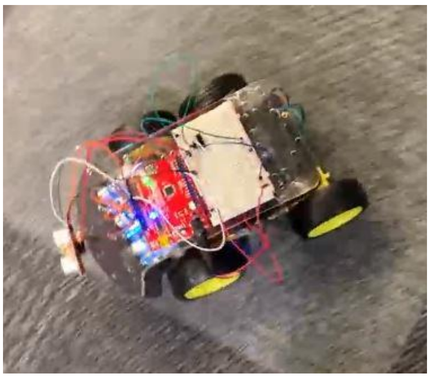
Test 5

Test	*Outcome*
1	*Left motors span forward, and right motors span backward.*
2	*Front motors span forward, and the back motors span backward.*
3	*Front-left and back-right motors span forward, and the front-right and back-left motors span backward.*
4	*All motors except back-left motor span forward.*
5	*All motors span forward.*

Figure 2.0: Table of Results



Final Outcome



Top View

After the third test, we knew which gear motor to change. The gear motors were changed by either switching places with other motors, switching input signals – wires or changing the placement, i.e. turning it around other ways. The latter was used to fix our issue. However, a new issue arose. The input wires were not long enough, especially the back-left wheel. Furthermore, this caused an issue with the arrangement/juxtaposition of the construction of the prototype. Therefore, the gear motors in our prototype are not equally proportionate, since two motors on the left are close together, whereas two motors on the right are far apart. However, the issue of the motors driving in the same direction was fixed. Other issues that stemmed from this were the breaking of wires, which was fixed by a soldering iron and tape, due to time constraints. A minor issue we faced before testing the prototype was code compiling errors. This was easily fixed by uploading the Arduino board on the IDE. Overall, despite the issues we had, the prototype was stable, balanced and continued to function as an autonomous car. Thus, we were able to replicate a self-driving car.

4.0 Discussion

4.1 RC Cars

The RC prototype/s demonstrate electric motor RC cars. It demonstrates the advantages and disadvantages of RC cars. For example, because it is electronic, the car is quiet and easier to operate. Speed can also be electronically operated rather than manually operated and there are laser sensors to sense the distance and speed – a limitation from our prototype. However, the issue with RC cars is that it because it runs on batteries, the batteries are depleted rapidly.

4.2 Autonomous Cars

The difference between an autonomous car and RC car is that people still have control over the movement of the car, whereas in an autonomous car, the car has complete control over its movement. The autonomous car prototype does demonstrate the advantages and concerns people have with self-driving cars. For example, the use of algorithms in the car can determine whether the car should move, stop, increase or decrease its speed and sense the distance of other vehicles, people and objects. Therefore, this dramatically decreases the chances of car accidents. On the other hand, the fragile construction of our prototype demonstrates the car not being able to function in all weather conditions. Moreover, heavy rain could do serious damage to the distance sensor on top of the car hence compromising the safety the individuals inside and outside of the vehicle. This leads to a question of morality; whether the driver or the engineer's technological failure of the car is accountable. Hence, leading to an ethical dilemma.

4.3 Comparing prototype to other research/work

Our findings agree with what others have shown compared to Tesla and Google. The reason why our findings agree is because the function of a self-driving car. Our prototype can sense object with its sensor and determines an appropriate action needed to proceed. This can be compared to Tesla cars as our prototype is quite similar in performance in comparison to theirs. The flaws we had in our experiment was the limitations of our prototype; including no sound for sensors, too few sensors and not being an IOT car. These can be easily fixed by implementing those limitations into our product.

4.4 New understanding

This was a learning experience for all members of our group but mainly Roshan and Leon as they had never used Arduino or made an autonomous car before. Azimah has had previous experience with using Arduino and C++ code before in a prior subject. Given our conclusion that we were successfully able to replicate both an autonomous car and a manually driven car we concluded that autonomous vehicles are in fact safer than manually driven cars.

4.5 Next Steps

With our outcome, further experiments would not be necessary since we have all the information needed. However, the next steps to further improve our prototype would be to fix all the limitations that we encountered during our current experiment. With all the limitations fixed, we can then provide more accurate information compared to how real self-driving cars work.

5.0 Conclusion

5.1 Further Improvements

From our project, we could have investigated and implement more sensors for safety precautions. Another sensor could have been integrated at the back of the vehicle that way it knows if there is something behind it, such as in a real-life scenario where a car is driving backward or trying to parallel park. Another aspect we could have interpreted is adding sound to our sensors so we know when it is reversing or increasing in speed, it can alert the user as it gets closer to an object. One final aspect we could have integrated is making our autonomous car an IOT car. By adding ways where we can evaluate its performance and upload its data to the cloud as well as connectivity.

5.2 Future Trends

The concept of self-driving vehicles has evolved from being remotely controlled in the 1920s to present day where it works autonomously and there is little to no interaction between the individual and the car. It is said that by 2020, there will be 10-million self-driving cars on the road. There is a huge market for autonomous car in many industries, such as Lexus and Audi. Autonomous cars are efficient and could solve problems like reducing traffic and pollution. On the other hand, the issue with self-driving vehicles is that it will be implemented in public transport. According to Musk, by 2020, Tesla will have 'Robotaxis' on the road. This is an issue as it reduces the number of working bus and taxi drivers.

5.3 Final Conclusion

Overall, autonomous cars are safer than RC and manual cars because there are no human errors in autonomous cars, meaning that the car cannot get distracted and there is no drunk-driving case stemmed from this. Also, autonomous cars have a set of rules within the code, whereas due to the unpredictability of humans, RC and manual cars are more dangerous.

6.0 References

Bhuiyan, J. (2018, May 17). Elon Musk says Tesla crashes shouldn't be front-page news because there are more human-driven fatalities. That's not an accurate comparison. Retrieved 22 May, 2019 from https://www.vox.com/2018/5/17/17362308/elon-musk-tesla-self-driving-autopilot-fatalities

'Complete Guide for Ultrasonic Sensor HC-SR04 with Arduino.' Retrieved 22 May 2019. https://randomnerdtutorials.com/complete-guide-for-ultrasonic-sensor-hc-sr04/

Dual H Bridge L298N Motor Driver Module | Lazada PH. (2018, October 9). Retrieved 21 May, 2019 from https://www.lazada.com.ph/products/dual-h-bridge-l298n-motor-driver-module-i103533146-s103952166.html

Everything You Need To Know About Remote Control Cars. (2018, April 17). Retrieved 22 May, 2019 from https://yourrcexpert.com/rc-cars-guide/

Garret, O. (2017, March 3). 10 Million Self-Driving Cars Will Hit The Road By 2020 -- Here's How To Profit. Retrieved 22 May, 2019 from https://www.forbes.com/sites/oliviergarret/2017/03/03/10-million-self-driving-cars-will-hit-the-road-by-2020-heres-how-to-profit/#95187417e508

Glon, R. (2019, April 26). Tesla Autonomous 'Robotaxis' Coming in 2020, Elon Musk says. Retrieved 22 May, 2019 from https://www.digitaltrends.com/cars/tesla-will-show-autonomous-tech-at-its-autonomy-investor-day/

Hartsman, A. (2016) How Google's self-driving car project rose from a crazy idea to a top contender in the race toward a driverless future. Retrieved May 15, 2019, from https://www.businessinsider.com/google-driverless-car-history-photos-2016-10/?r=AU&IR=T

LaFrance, A. 2016 Your Grandmother’s Driverless Car The driverless vehicles of the 1920s were called “phantom autos,” and they were remote-controlled by the tapping of a telegraph key. Retrieved May 15, 2019, from https://www.theatlantic.com/technology/archive/2016/06/beep-beep/489029/

SparkFun Motor Driver - Dual TB6612FNG (1A). (2018). Retrieved 21 May, 2019 from https://www.sparkfun.com/products/14451

Tesla (2019). Tesla’s mission is to accelerate the world’s transition to sustainable energy. Retrieved May 15, 2019, from https://www.tesla.com/en_NZ/about?redirect=no

Tesla was on Autopilot in fatal crash. (2018, March 31). Retrieved from https://www.bbc.com/news/world-us-canada-43604440

Meeting Minutes Template: 1

Time: 1.00pm Date: 28.03.19 Location: AUT Library

Goals of this meeting	
1	Choosing topic
2	Group presentation - proposal
3	Establishing roles

	Completed tasks since last meeting:	Team member name
1	/	

	What need to be done till next meeting:	Team member name
1	Arduino software download	Leon, Joao, Roshan
2	Arduino tools	Azimah
3	Purpose of the project	ALL

	Difficulties:	Possible solutions:	Problem solved?
1	/		Y/N

Meeting Minutes Template: 2

Time: 1.00pm Date: 4.04.19 Location: AUT Library

	Goals of this meeting
1	Arduino tutorial – testing the distance sensor and rgb light
2	Constructing – building a prototype of the car
3	Presentation - discussion

	Completed tasks since last meeting:	Team member name
1	Downloaded Arduino on laptops	Leon, Joao, Roshan
2	Purpose of the project	ALL
3	Bringing in tools	Azimah

	What need to be done till next meeting:	Team member name
1	Write purpose for the project	ALL
2	Fix broken wires and wheel	Azimah
3	Find sources for report	

	Difficulties:	Possible solutions:	Prob-lem solved?
1	Broken wires from the motor	Soldering iron or tape	Y/N
2	Wheel is stuck to the motor	Plyers	Y/N

Meeting Minutes Template: 3

Time: 1:00pm Date: 11/04/19 Location: Library Level 3

	Goals of this meeting
1	Test the motor drivers
2	Test the gear motors

	Completed tasks since last meeting:	Team member name
1	Found the sources for the report	Leon
2	Fixed broken wires and wheels	Azimah

	What need to be done till next meeting:	Team member name
1	Fix more broken wires	Azimah
2	Construct first prototype	Roshan and Leon
3	Upload the code to the car	Azimah

	Difficulties:	Possible solutions:	Problem solved?
1	Broken wires	Solder the wires again	Y/N

Meeting Minutes Template: 4

Time: 11.30am Date: 26.04.19 Location: AUT Library

	Goals of this meeting
1	2-wheel drive remote-control car
2	Comparing distance sensor and remote-control car - Discussion
3	Presentation/report - discussion

	Completed tasks since last meeting:	Team member name
1	Constructing the car	Leon and Roshan
2	Wiring the car	ALL
3	Uploading code on the car	Azimah

	What need to be done till next meeting:	Team member name
1	Report	ALL
2	Fix broken wires and wheel	Azimah
3	Code distance sensor	Azimah

	Difficulties:	Possible solutions:	Problem solved?
1	Broken wires from the motor and battery pack	Soldering iron or tape	Y/N

Meeting Minutes Template: 5

Time: 12.30pm Date: 2.05.19 Location: AUT Library

	Goals of this meeting
1	4-wheel drive remote-control car
2	Comparing distance sensor and remote-control car - Discussion

3	Adding distance sensor on car

	Completed tasks since last meeting:	Team member name
1	Constructing the car	Leon and Roshan
2	Wiring the car	Leon and Roshan
3	Uploading code on the car	Azimah

	What need to be done till next meeting:	Team member name
1	Debug code	Azimah
2	Start Report	ALL
3	Findings for report	ALL

	Difficulties:	Possible solutions:	Problem solved?
1	Code not compiling	Fix serial port	Y/N
2	Wheels not moving the same way and speed	Switch gear motors around	Y/N

Meeting Minutes Template: 6

Time: 1pm Date: 9.05.19 Location: Pod 1

	Goals of this meeting
1	Report structure - discussion
2	Report roles
3	Image and video files

	Completed tasks since last meeting:	Team member name
1	Compiling code	Azimah
2	Background research	Leon
3	Swapping gears motors	ALL

	What need to be done till next meeting:	Team member name
1	Start report	ALL
2	Findings for report	ALL

	Difficulties:	Possible solutions:	Problem solved?
1	Understanding the requirements for the report.	Highlighting and breaking down points	Y/N

Meeting Minutes Template: 7

Time: 1pm Date: 16.05.19 Location: Pod 2

	Goals of this meeting
1	Report structure - discussion
2	Report progress
3	Image and video files

	Completed tasks since last meeting:	Team member name
1	Structure	Azimah

2	Established Roles	ALL

	What need to be done till next meeting:	Team member name
1	Start presentation prep	ALL

	Difficulties:	Possible solutions:	Problem solved?
1	/	/	Y/N

Meeting Minutes Template: 8

Time: 3.00pm Date: 21.05.19 Location: Pod 1

	Goals of this meeting
1	Presentation structure - discussion
2	Presentation roles
3	Image and video files

	Completed tasks since last meeting:	Team member name
1	PPT	Azimah
2	Findings research	ALL

	What need to be done till next meeting:	Team member name
1	Finish ppt slides	ALL
2	Make script for presentation	ALL

	Difficulties:	Possible solutions:	Problem solved?
1	/	/	Y/N

Meeting Minutes Template: 9

Time: 1pm Date: 23.05.19 Location: AUT Library Level 3

	Goals of this meeting
1	Presentation prep/rehearse
2	Uploading video files
3	Assembling autonomous car

	Completed tasks since last meeting:	Team member name
1	PPT slides	ALL
2	Script	ALL

	What need to be done till next meeting:	Team member name
1	Report	ALL

	Difficulties:	Possible solutions:	Problem solved?
1	Wires breaking from gear motor	Last minute problem solved by tape	Y/N
2	Fragile construction	Tape	Y/N

Meeting Minutes Template: 10

Time: 1pm Date: 28.05.19 Location: Pod 1

	Goals of this meeting
1	Updated Report Structure

	Completed tasks since last meeting:	Team member name
1	Presentation	ALL

	What need to be done till next meeting:	Team member name
1	All Findings	ALL
2	Intro	ALL
3	Discussion and Conclusion	ALL

	Difficulties:	Possible solutions:	Problem solved?
1	/	/	Y/N

Meeting Minutes Template: 11

Time: 1pm Date: 23.05.19 Location: AUT Library Level 3

	Goals of this meeting
1	Finishing the body of the report
2	Finish whole report

	Completed tasks since last meeting:	Team member name
1	Findings, Intro, Discussion and Conclusion	ALL
2	Script	ALL

	What need to be done till next meeting:	Team member name
1	/	/

	Difficulties:	Possible solutions:	Problem solved?
1	/	/	Y/N