AUTONOMOUS TAXI

Capstone Project Report

End-Semester Evaluation

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Patiala

December 2021

ABSTRACT

Over the last years, the automotive industry has advanced significantly towards a future without human drivers. Researchers are currently trying to overcome the technological, political and social challenges involved in making autonomous vehicles mainstream. These vehicles need to be safe, reliable and cost efficient. Connecting them and creating coordination mechanisms could help achieving these goals. Combining the autonomous vehicle, the cab booking system and conventional taxis into one, we have autonomous taxis.

A website is employed for connecting the customers with our organization for booking the taxi as and when required. Apart from this, it also has multifarious purposes such as by connecting with large databases,it helps to track the number of users visiting our website and moreover,this idea might also bring a giant leap in the transport industry in the forthcoming generations.

A path planning model is trained for the self-driving car in the open source self driving car simulator that is provided by Udacity. The project aims to significantly reduce travel time and increase security for autonomous vehicles as well as proper following of traffic rules by the autonomous car.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled **Autonomous Taxi** is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Anil Kumar Verma during 6th and 7th semester (2020-21).

Date: 16/12/21

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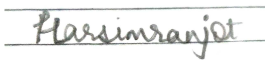
101803224	Harsimranjot	
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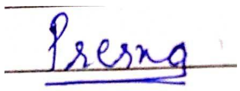
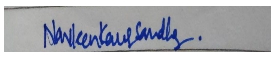
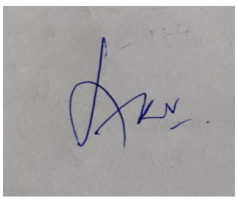
101803332	Prerna Puri	
101853032	Navleen Kaur	



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ACKNOWLEDGEMENT

We would like to express our gratitude to Dr. Anil Kumar Verma. He has been of great help in our venture, and an indispensable resource of technical knowledge. He is truly an amazing guide.

We are also thankful to Dr. Maninder Singh, Head of Computer Science and Engineering Department, entire faculty and staff of Computer Science and Engineering Department, and also our friends who devoted their valuable time and helped us in all possible ways towards successful completion of the project. We also express our thanks to all those who have contributed either directly or indirectly towards this project.

Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us and we admire their determination and sacrifice.

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GPS	Global Positioning System
CNN	Convolutional Neural Network
IEEE	Institute of Electrical and Electronics Engineers

INTRODUCTION

1.1 Project Overview

Everybody in this world is concerned about safety. The people who go out from one place to another, expect to reach safely without any sudden incidents which may come through externally by road accidents while traveling. So in order to increase safety a lot of focus has been towards developing Autonomous or Driverless Cars.

An autonomous car is a vehicle that is capable of sensing the environment on its own and is capable of making driving decisions.These cars work without any human inputs or interactions.The cars rely on sensors and complex algorithms to identify pathways, obstacles and pedestrians from the surroundings. An automated car is able to handle all driving tasks in all modes and in all the environmental conditions just like human drivers.

Fully automated cars have a lot of potential and the scenarios for convenience and quality-of-life improvements are limitless. The elderly and the specially abled would have independence. They also have the potential for dramatically lowering the carbon dioxide emissions. Also these cars can reduce labor costs and also relieve drivers from driving and navigation chores, thereby replacing behind-the-wheels commuting hours with more time for leisure or work.

Autonomous car development is rising rapidly in the automotive industry. They are increasingly catching attention worldwide because the future prospects of this technology are clear as it will dramatically change transportation by minimizing traffic jams, increasing efficiency and allowing faster speeds. Autonomous cars are predicted to increase traffic flow and lower fuel consumption which will reduce contamination in urban areas by improving driving and significantly reducing the need for parking space. In addition, autonomous cars will increase security, specifically significant reduction in traffic collisions by reducing human error.

In this project we are trying to take autonomous cars one step ahead by implementing an autonomous taxi. This taxi would eliminate the need for human drivers ,which represents a significant part of the operating costs of such services and would make it affordable for customers.

Since governments, industries, and research institutions are investing vast amounts of both human-time and money, we can make an idea of the interest that autonomous driving is raising and pushing its limits. Fully autonomous vehicles have become a reality, as for example by October 2018, it was revealed that Waymo's self-driving cars had driven more than 10 million miles on public roads.The Institute of Electrical and Electronics Engineers (IEEE) predicts that driverless cars will account for up to 75% of vehicles on the road by the year 2040.

Automated cars could reduce labor costs relieve travelers from driving and navigation chores, thereby replacing behind-the-wheel commuting hours with more time for leisure or work and also would lift constraints on occupant ability to drive, distracted and texting while driving, intoxicated, prone to seizures, or otherwise impaired. For the young, the elderly, people with disabilities, and low-income citizens, automated cars could provide enhanced mobility. The removal of the steering wheel-along with the remaining driver interface and the requirement for any occupant to assume a forward-facing position-would give the interior of the cabin greater flexibility. Large vehicles, such as motorhomes, would attain appreciably enhanced ease of use.

Despite the various benefits to increase vehicle automation, there is a lot more. work to be done before self-driving cars are ready for the mainstream systems. As the self-driving car is a collection of networked computers wirelessly connected to the outside world, the most daunting challenge is keeping the systems safe from intruders i.e. Cyber Security. Similarly disputes concerning liability, driving safely despite unclear lane markings or recognize traffic lights that are not working Other obstacles could be missing driver experience in potentially dangerous situations, ethical problems in situations where an autonomous car's software is forced during an unavoidable crash to choose between multiple harmful courses of action, and possibly insufficient adaptation to respond to spoken commands or hand signals from pedestrians or highway safety employees.

Autonomous cars today are intelligent enough to drive around the city with very low chances of crashing, that is great but there are some limitations which they are bound with, that they are limited to GPS, Google Maps or similar. In this project, we are focusing on the learning process of a self-driving car as well as a taxi booking system. We have specified a road environment and will train the car using deep learning by extracting road features with some real world obstacles and constraints and let the car learn the whole state by itself from zero to pro.

In our first model we used a Convolutional Neural Network (CNN) to train a self-driving car in the open source self driving car simulator that is provided by Udacity. Using this simulator we'll first drive the car and collect some data and using this data we'll train a CNN model proposed by NVIDIA to learn the patterns and then test it back on the simulator. In the model proposed by NVIDIA, a CNN model that goes beyond pattern recognition was proposed. The model learns the entire pipeline needed to steer an automobile.

In our second and final model the car is provided with a set of data points with the information about its x coordinates, y coordinate and distance and using those data points the car navigates on the highway. The car transmits its location, along with its sensor fusion data, which estimates the location of all the vehicles on the same side of the road. A tally of the number of vehicles in the immediate environment is kept and the car changes its lane accordingly in order to avoid collisions, stay in lane, maintain a speed of less than 50 mph and minimum acceleration and jerk. We make a smooth and safe trajectory for the car to follow.

1.1.1 Technical Terminology

- **Convolutional Neural Network (CNN):** In neural networks Convolutional neural network is one of the main categories to do image recognition, images classifications. Object detections, recognition faces etc. Are some of the areas where CNNs are widely used.
- **Cyber Security:** Cyber security refers to the body of technologies, processes and practices designed to protect networks, devices, programs, and data from attack, damage or unauthorized access.

1.1.2 Problem statement

India has a serious problem of mobility. Busy roads, packed parking lots, signal jumping, potholes and so on. These problems have been persistent over the decades. Apart from this there is an increase in the number of accidents and concerns regarding safety of people during driving. For all these reasons it is extremely necessary to bring Driverless Cars as they have shown potential to improve this. Also these cars can be taken one step ahead and can be used to develop the concept of Driverless Taxis. These taxis would help to reduce the operational costs and would guarantee increased safety along with many other benefits. Thus accounting to above mentioned problems, we need to develop the concept of Driverless Cars which can be further developed into much more things like taxis.

1.1.3 Goal

Our goal is to develop a self-driving taxi which would help to reduce the operational costs and would guarantee increased safety along with many other benefits.

1.1.4 Solution

The solution for the problem statement is to develop an autonomous taxi which is self driven. This will help in minimizing accidents on the roads and help in reducing the number of lives lost on roads due to sheer negligence of the driver. It will also help to reduce traffic congestion and also solve the space constraints of parking.

1.2 Need Analysis

The most weighted argument in favor of the need for this technology is that we want to reduce unfortunate accidents on roads due to human negligence. When we look at other drivers on the road, most of them drift into other lanes when they are playing with their phone, with the radio, talking with a passenger, falling asleep, etc. Look at how many people die in traffic accidents.

Now imagine a world where the computers are driving all the cars. The only accidents will be from car failures (if the wheel falls off or there is a wheel. burst it isn't going to matter much who is driving), sensor failures (the computer can't see the road or other cars), or software bugs. The latter will only happen once because it gets added to a regression test and all the cars running that software automatically learn how to avoid that mistake.

Consider how traffic slows down just because there is an accident off to the side, or people slamming on brakes because they weren't paying attention to the car in front of them or someone cut in front of them. Computers won't have. any of that, so high-traffic areas would be much more efficient, cars will take minutes to pass through the area, so traffic will be better too.

Driverless taxis could drastically reduce greenhouse gas emissions from our transit system in the not-so-distant future, according to a new study.

Perhaps the biggest environmental benefit that can be gained from autonomous vehicle involves breaking up the car ownership culture and replacing it with a seamless and affordable autonomous taxi service that dispatches robots to whisk people to their destinations, whether work or a weekend getaway, picking them up and dropping them off much as a bus would, but with personalized, convenient stops.

These driverless taxis will also help the old and aged people who cannot drive and rely on their children or other people to go somewhere. They no longer have to be dependent on anybody else and carry out the tasks on their own.

Automation resolves the problem of human weaknesses. We put mirrors in cars because we do not have eyes in the backs of our heads. Now, we can put sensors and cameras in cars that will give us much better information. We can combine these sensors with braking and steering systems to automatically prevent collisions. We can connect vehicles to have real-time information on road conditions "over the horizon". Self-driving cars don't need to park close to where you want to get out. This would be important in cities where parking is an issue. Traffic is often made worse because of people driving around in circles looking for a parking space. If most self-driving vehicles in city centers were shared, the cars would hardly need to park at all but could drop you where you want to get out and then go off to pick up another customer. As a result, crowded cities might be able to get rid of most on-street parking altogether and reclaim a lot of space for more useful and pleasant purposes.

Autonomous Taxis will also help the old and aged people who cannot drive and rely on their children or other people to go somewhere. They no longer have to be dependent on anybody else and carry out the tasks on their own.

1.3 Research Gaps

Driving requires many complex social interactions which are still tough for robots. A far more difficult hurdle, meanwhile, is the fact that driving is an intensely social process that frequently involves intricate interactions with other drivers, cyclists, and pedestrians. In many of those situations, humans: rely on generalized intelligence and common sense that robots still very much lack. Much of the testing that Google has been doing over the years has involved "training the cars software to recognize various thorny situations that pop up on the roads. But there are thousands and thousands of other challenges that pop up, many of them quite subtle and unpredictable.

Bad weather makes roads trickier. Compounding these challenges is the fact that weather still poses a major challenge for self-driving vehicles. Much like our eyes, car sensors don't work as well in fog or rain or snow.

Cybersecurity will likely be an issue though a surmountable one. As vehicles get smarter and more connected, there are more ways to get into them and disrupt what they're doing.

1.4 Problem Identification and Scope

The current driving system is very dangerous for human beings. It is dangerous for those in front of the wheel and those behind the wheel. People drive cars recklessly without worrying about the repercussions one will have to face in case of unforeseen circumstances. To reduce the number of accidents on the road and decrease the number of lives lost due to road rage cases, we intend to develop technologies which require minimal human interaction and can perform the assigned task of driving the car on their own.

The scope of the project is limited to logging in/ signing up and booking a taxi through the website. On the other side, the path for the car to travel on is predefined. A file containing the x and y coordinates along with the distance is used to get the location every 0.02 second. The spacing between the x and y coordinates determine the speed of the car. We take the difference from the next point of the current point to decide the angle of the car in the upcoming second. The tangential and normal acceleration is measured as well as the jerk helps in deciding the total acceleration of the car. The simulator that we use has a constraint on the jerk. It cannot go over 10 m/s^2 as well as the acceleration, which cannot go over 50 m/s^2.

1.5 Assumptions and Constraints

- Our project is quite small-scaled and also due to the pandemic, we decided to use an autonomous car simulator to simulate the car .
- Aforementioned so it wasn't possible to test the results in a real time environment since the simulator provides a simulated environment.
- The project is somewhat limited to the ability of the simulator.
- The car's maximum speed limit is 50mph on the highway.
- It does not exceed a total acceleration of 10 m/s^2.
- It does not exceed a total jerk of 10 m/s^3.
- It does not have collisions with any of the cars while changing lanes or driving inside a lane.
- The car stays in its lane, except for the time between changing lanes.
- If the car ahead is moving slow, then we should be able to change lanes.
- The car does not turn around.

1.6 Approved Objectives

- Self-drive on track.
- If there is an empty lane, the car will switch to it.
- The car will maintain a minimum jerk.
- The car will try to avoid collision with other cars.
- The car will keep a tally of the number of other cars in the immediate environment.
- The customer can sign up through the website.
- The customer can login on the website.
- The customer can book a taxi through the website.

1.7 Methodology Used

After the successful sign up by the user, users can then input their locations and check the estimated fare according to the distance. The user will be asked the option of 'Ride Now', which on selection will confirm the booking. The request placed by the customer is shared with the server and it will find the nearest available taxi and confirm the booking. The customer will get the confirmation message and can also track the taxi via the map.

The path for the car to travel on is predefined. A file containing the x and y coordinates along with the distance is used to get the location every 0.02 second. The spacing between the x and y coordinates determine the speed of the car. We take the difference from the next point of the current point to decide the angle of the car in the upcoming second. The tangential and normal acceleration is measured as well as the jerk helps in deciding the total acceleration of the car. The simulator that we use has a constraint on the jerk. It cannot go over 10 m/s^2 as well as the acceleration, which cannot go over 50 m/s^2.

1.8 Project Outcomes and Deliverables

Project outcomes and deliverables:

- Deliver a website and a self driving taxi for the customer to book.
- Counting the number of cars in the immediate environment.
- Calculating the upcoming velocity, acceleration and jerk.
- Making sure the car stays in the lane.
- Switching lane if there is a chance of collision or there is an empty lane.
- Avoiding possible collisions.
- A smooth and safe trajectory for the car to drive on.
- Safe and secure vehicles in the coming times which can help reduce the number of crimes with women.
- Develop a website for customers to book taxis for themselves.
- Making it easier for the customers to get a taxi at odd times.
- The issues related to driver availability are also resolved by this idea.

- Also help in reducing consumption of fuels.
- This project can become a great business venture if implemented on a large scale in the coming future.

1.9 Novelty Of Work

The main objective of the project is to deliver a project integrated with different parts of computer science and to gain an insight of how different branches of computer science can be correlated with each other to embark on a full proof system. The project involves neural networks and machine learning as well as image processing. With the help of our system, we intend to reduce traffic congestion as well as parking issues prevalent in our cities. With the Smart India initiative of the Government of India, self- driving cars will provide a good step to automate the cities. The novelty of our system is to prevent collisions in any given case as well as to develop a system in which all the cars will follow the traffic rules properly and there will be no traffic violations in our system. It will also solve the problem of lack of availability of drivers at late nights and the safety issues women face while traveling through a taxi.

REQUIREMENT ANALYSIS

2.1 Literature Survey

2.1.1 Theory Associated with Problem Area

A research with the title “Autonomous Vehicles” was done. The strength of this research is that it reduces human error while driving and results in a decreasing possibility of accidents occurring. Better fuel efficiency is also achieved when more and more autonomous vehicles are promoted which will lead to changes in driving habits of the masses. Destination can be achieved in a short duration of time and moreover the safety algorithms applied make these vehicles more secure. As autonomous-vehicle technologies advance, conventional taxi and car-sharing services are being combined into a shared autonomous vehicle service, and through this, it is expected that the transition to a new paradigm of shared mobility will begin. However, before the full development of technology, it is necessary to accurately identify the needs of the service’s users and prepare customer-oriented design guidelines accordingly. "Autonomous Taxi Service Design and User Experience" by Sangwon Kim, Jennifer Jah Eun Chang, Hyun Ho Park, Seon Uk Song, ChangBae Cha, Ji Won Kim & Namwoo Kang[1] is concerned with the following problems:

- How should an autonomous taxi service be designed and field-tested if the self-driving technology is imperfect?
- How can imperfect self-driving technology be supplemented by using service flexibility?

This study implements an autonomous taxi service prototype through a Wizard of Oz method. Moreover, by conducting field tests with scenarios involving an actual taxi, this study examines customer pain points, and provides user-experience-based design solutions for resolving them.

"Routing an Autonomous Taxi with Reinforcement Learning" by Miyoung Han, Pierre Senellart, Stéphane Bressan and Huayu Wu [2] proposed that the design and implementation of intelligent routing algorithms is one of the keys to the deployment of autonomous taxis. They demonstrate that a reinforcement learning algorithm of the Q-learning family, based on a customized exploration and exploitation strategy, is able to learn optimal actions for routing autonomous taxis in a real scenario at the scale of the city of Singapore with pick-up and drop-off events for a fleet of one thousand taxis.
"Impacts of Shared Autonomous Taxis in a Metropolitan Area" by Wilco Burghout, Pierre-Jean Joseph Rigole and Ingmar Andreasson[3] provided an analysis of potential benefits of a fleet of shared autonomous taxis "aTaxis" when replacing private car commuter trips in a metropolitan city.

2.1.2 Existing Systems and Solutions

Currently autonomous vehicles use infrared cameras or radar to detect the hurdles encountered in the way. But with the grace of technical advancements, autonomous vehicles could possibly use the combination of cameras, radar and lasers to navigate the hurdles encountered in their way like the traffic problems,small spots like bus only lanes, walking pedestrians or roaming animals like cows, dogs etc.
So, moving a step further, we can also make use of these autonomous vehicles like cars etc as taxis in order to make means of transportation fast due to its advantages like easy detection of obstacles due to internet linked navigation systems which actually help us follow variable speed limits. Moreover,since no human interference is involved we can book taxis at odd times as well eliminating the need for availability of drivers. Since these days women empowerment and safety is also a burning issue, it also solves this problem by which women can safely travel alone late at night.

2.1.3 Research Findings for Existing Literature

Table 1: Literature Survey

S. no.	Roll number	Name	Paper title	Tools/ Technology	Findings	Citation
1	101803224	Harsimranjot	Self-driving cars could account for 75% of all vehicles on the roads by 2040	Future of autonomous cars	The report suggests quite a bright future	Focazio[4]
2	101803330	Disha Jindal	Autonomous Taxi Service Design and User Experience	How should autonomous taxi service be designed and field-tested if the self-driving technology is imperfect?	Provides user experience for solving the issue	Sangwon Kim [1]

3	101803332	Prerna Puri	Routing an Autonomous Taxi with Reinforcement Learning	Proposed that the design and implementation of intelligent routing algorithms is one of the keys to the deployment of autonomous taxis.	Demonstrated that a reinforcement learning algorithm of the Q-learning family is able to learn optimal actions for routing autonomous taxis in a real scenario.	Miyoung Han [2]
4	101853032	Navleen Kaur	Impacts of Shared Autonomous Taxis in a Metropolitan Area	Analysis of potential of shared autonomous taxis.	It was a successful operation as it saved money as well as was beneficial to the environment.	Wilco Burghout [3]

2.1.4 Problem Definition

Trust in Technology: The literature on technology adoption uncovers various factors impacting trust in technology.

Performance Expectancy: As fully autonomous vehicles have not been developed, their performance is difficult to predict. Since any failure of one of the components or sensors can cause a fatal accident or crash, automated taxis need to have high performance requirements.

Reliability: Their reliability is only constrained by the technology and computing power that they carry.

Security: Certain measures will need to be undertaken, as self driving cars will have security risks.A self-driving car may be vulnerable to traffic mishaps and disruptions,car-jacking, broken equipment as well as software related security flaws as in car hacking, remote access,remote control of the vehicle, computer virus's malwares, spoofing, excessive targeted marketing and in car product environments.

Privacy: Autonomous vehicles are an idea of autonomy away from humans. This loss of autonomy extends to loss of privacy. These vehicles could transmit private data of a user like their location or past travel patterns or their future travel plans, subjecting the user to targeted marketing or law enforcement.

2.1.5 Survey of Tools and Technologies Used

Autonomous systems make use of many technologies in order to perform its function efficiently and safely. Technologies being used to implement autonomous taxi are as follows:

- Path Planning
- SQLite
- PHP
- HTML
- CSS
- Javascript
- jQuery
- SQL

2.2 Standards Used

- Quality assurance Necessities Ensuring commitment from all team members, maintain quality control at each stage
- Cost management
- Calculating and maintaining cost of resources and training required
- Reports will be made according to IEEE standards
- Metric system will be followed.

2.3 Software requirements specification

2.3.1 Introduction

You must have waited for cabs when you are supposed to go somewhere and you are in a hurry or the weather conditions are bad or there is some unrest (religious, political, etc.) going on the roads. These are the very few problems faced by one while taking a ride. It's a time consuming process which at times irritates customers.

To resolve many such problems there is an online cab booking system introduced. The location of pick-up and destination is known from before, which makes the entire process very smooth and user-friendly ensuring the comfort of the customer.

2.3.1.1 Purpose:

With thousands of accidents happening everyday throughout the world due to a lot of traffic or people not following the traffic rules is a major concern right now. These road accidents lead to instant death of the person at the spot. With an increase in the number of private vehicles and more and more people not following traffic rules the accident rate is increasing tremendously. Moreover with the initiative of smart India we need to take care of this problem of accidents as we can't have a sman India with these problems. Also one more purpose is as the people who are unable to drive the cars will be helped through this product.

Cab booking is a booming business that has the potentiality to generate huge revenue using Cab Booking Software, instead of the traditional cab hailing system. One can enhance the quality of service as well by streamlining and automating the processes by taking advantage of such technology. Our feature loaded and fast Cab Booking Application is efficient enough to handle the intricacies of the simultaneously running processes that ensures smooth growth of the business and reduces the downtime.

There are different ranges of cabs available according to one’s preference. As the internet users are increasing exponentially, companies have introduced Online Cab Booking systems. This system improves customer’s experience but also eases the hassles of a customer while taking a ride.

Cab booking software has research driven features and functionalities that will lessen your effort to reduce overall cost, while it will improve productivity, smoothen the booking procedure and enhance profitability of your company.

2.3.1.2 Intended audience and reading suggestions:

As with the Initiative of smart India where the problem of traffic congestion and parking will be negligible and people strictly follow traffic rules. So our project will help in following these conditions of smart India. So our intended audiences are the people taking initiative to build smart India and also the old aged people or the people who are unable to drive the cars. Our product will be very beneficial for these people

2.3.1.3 Project Scope

In this project we are creating a website for taxi booking and implementing a Self Driving Car which has the capability of moving in one direction. The path for the car to travel on is predefined. A file containing the x and y coordinates along with the distance is used to get the location every 0.02 second. The spacing between the x and y coordinates determine the speed of the car. We take the difference from the next point of the current point to decide the angle of the car in the upcoming second. The tangential and normal acceleration is measured as well as the jerk helps in deciding the total acceleration of the car. The simulator that we use has a constraint on the jerk. It cannot go over 10 m/s^2 as well as the acceleration, which cannot go over 50 m/s^2. The car stays in the same lane as long as there is no chance of collision with any other car or if there is an empty lane. The car stays in the lane, avoids colliding with other cars, maintains a tally of the number of cars in the immediate vicinity and also maintains a speed limit. The website is a full stack website that allows users to register themselves using a valid email ID and then they can sign in to the website. Once a user is logged in they can put their pickup and drop location and depending on the distance between locations, an estimated fare is calculated. The cars will be equipped with QR code scanners that would handle the payments once the ride has finished.

2.3.2 Overall Description

2.3.2.1 Product perspective: In this project we will be making a Self Driving Car. The car stays in the same lane as long as there is no chance of collision with any other car or if there is an empty lane. The car stays in the lane, avoids colliding with other cars, maintains a tally of the number of cars in the immediate vicinity and also maintains a speed limit. To resolve many such problems there is an online cab booking system introduced. The location of pick-up and destination is known from before, which makes the entire process very smooth and user-friendly ensuring the comfort of the customer.

2.3.2.2 Product Features:

In this product, the user will be able to book a taxi from the website. The autonomous taxi will stay in the lane, keep a tally of the number of cars in the immediate vicinity and try to stop collisions with other cars while maintaining a straight trajectory and a speed limit. The website allows users to register themselves using a valid email ID and then they can sign in to the website. Once a user is logged in they can put their pickup and drop location and depending on the distance between locations, an estimated fare is calculated. The cars will be equipped with QR code scanners that would handle the payments once the ride has finished.

2.3.3 External Interface Requirements

2.3.3.1 User interface:

User interface will be very user friendly. It will be easy to use and easily understandable by anyone with a basic understanding of computers.

2.3.3.2 Hardware Interface:

There is no hardware involved in the project.

2.3.3.3 Software Interface:

Software requirements include the Windows operating system. This Software aspect of the project is being developed using C++ and python libraries.The website is built using PHP as backend technology and HTML,CSS,Javascript as front end technology.

Table 2: Software Interface

Front End	**Platform**	**Back End**	**Web Browser**	**Database**
HTML,CSS, HTML5, JAVASCRIPT & JQUERY	Windows 10 x64	PHP	Google Chrome	MYSQL

2.3.4 Other non-functional requirements

2.3.4.1 Performance requirements:

Car movement prediction should be completed fast. Accuracy must be above 95%. The car should avoid colliding with other cars, keep an accurate tally of the number of cars in the immediate vicinity and stay in the lane. Tasks should be performed as intended and any deviation from its required path could result in failure.

The website should be able to register the new users and store their information in the database and once logged in should let the users book a cab for their intended location.

2.3.4.2 Safety requirements:

Although our project is at smaller scale so we are not going to have any real time problems but we need take of all the safety measures we need for
large scale application of this project.

2.3.4.3 Security requirements:

The jerk and acceleration of the taxi must not exceed or it may lead to swerwing of the taxi into other cars causing accidents.

Requirements about protection of your system and its data. The measurement can be expressed in a variety of ways (effort , skill level , time) to break into the system. Do not discuss solutions (e.g. passwords) in a requirements document.Only secured users can access the application.No one can go to any independent page without logging in. Also,there may be legal issues involving privacy of information, intellectual property rights, export of restricted technologies, etc.

2.4 Cost Analysis

Since the autonomous car side of our project was done on a simulator, there was no capital involved.

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2.5 Risk Analysis

Table 3: Risk Analysis

Hazard	**Solution**
Inaccurate prediction of car movement.	Complete testing before deployment.

METHODOLOGY ADOPTED

3.1 Investigative Techniques

- Studying the current system documentation
- Reading a lot of research papers
- Questionnaires
- Observation of the system in operation
- Reviewing previous studies

The investigative technique under which our project is based is experimental. The project is based on a self-driving car model which is made by experimenting again and again till the car starts moving independently and intelligent enough to detect traffic signals etc. During the first stage of the project we had to perform different experiments and perform different combinations of layers in the CNN model. The training data for our model contains single image samples from the simulator paired with the corresponding steering angle command. The model will train itself based on this data and it will try to learn and generalize as much as it can. To do other than just stay in lane and move forward by changing its steering angle, we had to shift to a different simulator and try a different approach. In this new model, the taxi is provided with a set of data points with the information about its x coordinates, y coordinate and distance and using those data points the car navigates on the highway. The car transmits its location, along with its sensor fusion data, which estimates the location of all the vehicles on the same side of the road. A tally of the number of vehicles in the immediate environment is kept and the car changes its lane accordingly in order to avoid collisions, stay in lane, maintain a speed of less than 50 mph and minimum acceleration and jerk. We make a smooth and safe trajectory for the car to follow. The tangential and normal acceleration is measured as well as the jerk helps in deciding the total acceleration of the car. The simulator that we use has a constraint on the jerk. It cannot go over 10 m/s^2 as well as the acceleration, which cannot go over 50 m/s^2. In brief, the car stays in the same lane as long as there is no chance of collision with any other car or if there is an empty lane. The car stays in the lane, avoids colliding with other cars, maintains a tally of the number of cars in the immediate vicinity and also maintains a speed limit.

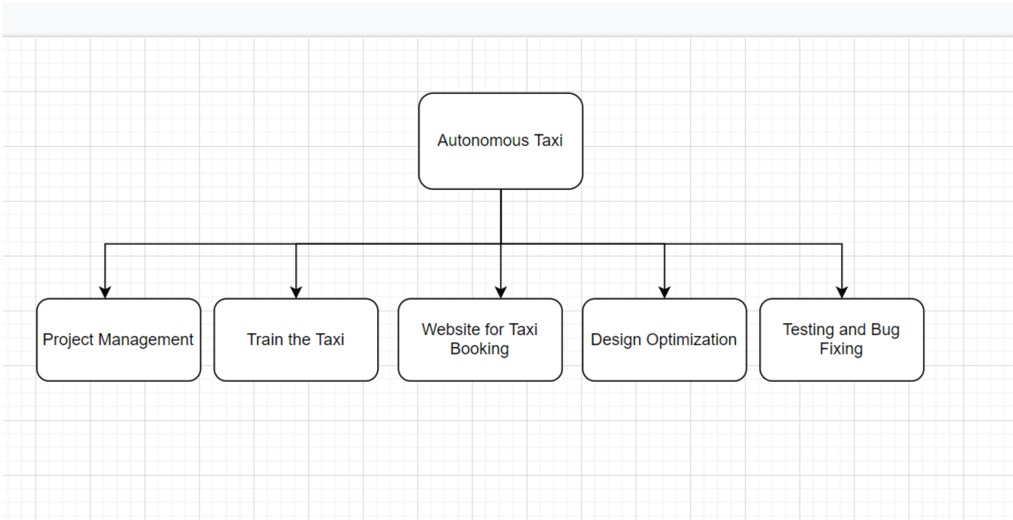
3.2 Proposed Solution

We are focusing on making a website that will offer an e-place to search the nearest travels around your living place and book an autonomous taxi for your safe journey. The website allows new users to register themselves and stores their data in a database. Once a user is logged in they can not only book a cab for themselves but also access the user dashboard. Depending upon the pickup and drop locations an estimated fare is calculated for the ride.

The taxi is provided with a set of data points with the information about its x coordinates, y coordinate and distance and using those data points the car navigates on the highway. The car transmits its location, along with its sensor fusion data, which estimates the location of all the vehicles on the same side of the road. A tally of the number of vehicles in the immediate environment is kept and the car changes its lane accordingly in order to avoid collisions, stay in lane, maintain a speed of less than 50 mph and minimum acceleration and jerk. We make a smooth and safe trajectory for the car to follow. The tangential and normal acceleration is measured as well as the jerk helps in deciding the total acceleration of the car. The simulator that we use has a constraint on the jerk. It cannot go over 10 m/s^2 as well as the acceleration, which cannot go over 50 m/s^2. In brief, the car stays in the same lane as long as there is no chance of collision with any other car or if there is an empty lane. The car stays in the lane, avoids colliding with other cars, maintains a tally of the number of cars in the immediate vicinity and also maintains a speed limit.

3.3 Work Breakdown Structure

Fig. 1: Work Breakdown Structure



3.4 Tools and Technology Used

Udacity Term 3 Simulator: Uacity term 3 simulator is used for the final model of our project. This simulator was built for Udacity's Self-Driving Car Nanodegree, to teach students how to train cars and how to navigate road courses using deep learning. The simulator is used to test our model and to visualize how it would perform if the taxi were put in a situation similar to that simulated by the simulator.

Motion Control: The responsibility of this module is to make sure that the car drives along a provided trajectory. We provide it with the trajectory that the car should follow and it responds with actuator controls such as the steering, throttle, brake that the car should follow to stay in lane and avoid collisions.

Sensor Fusion: The responsibility of this module is to detect stationary and moving objects around the car. The car gets the sensor data and using that data it figures out the location and movement of the other vehicles around it.

Localization: Localization is used to determine the location of the car. It also determines the orientation and the speed of the car. It takes in the maps, GPS data & Sensor Fused data and returns the location, orientation and speed of the car.

Prediction: It predicts the future locations and motion of objects around the car by taking in the maps, Sensor Fusion & Localization data and determines the trajectories of the objects (other vehicles) with associated probability.

Behavior Planner: This module suggests maneuvers which are feasible, safe, legal and efficient for our taxi to follow by taking in the maps, routes, localization and prediction data.

Trajectory: For each suggested maneuver in the behavior planner module, this defines a trajectory and selects the best trajectory that the car should follow by taking in the maps, routes, localization, prediction data and behavior planning.

Front end: HTML, CSS, JavaScript

- **HTML:** HTML is used to create and save web documents.
- **CSS : (Cascading Style Sheets)** Create attractive Layout
- **JavaScript:** it is a programming language, commonly used with web browsers.

Back end: PHP, MySQL

- **PHP:** Hypertext Preprocessor (PHP) is a technology that allows software developers to create dynamically generated web pages, in HTML, XML, or other document types, as per client request. PHP is open source software.
- **MySQL:** MySql is a database, widely used for accessing querying, updating, and managing data in databases.

Fig 2: Techniques Used

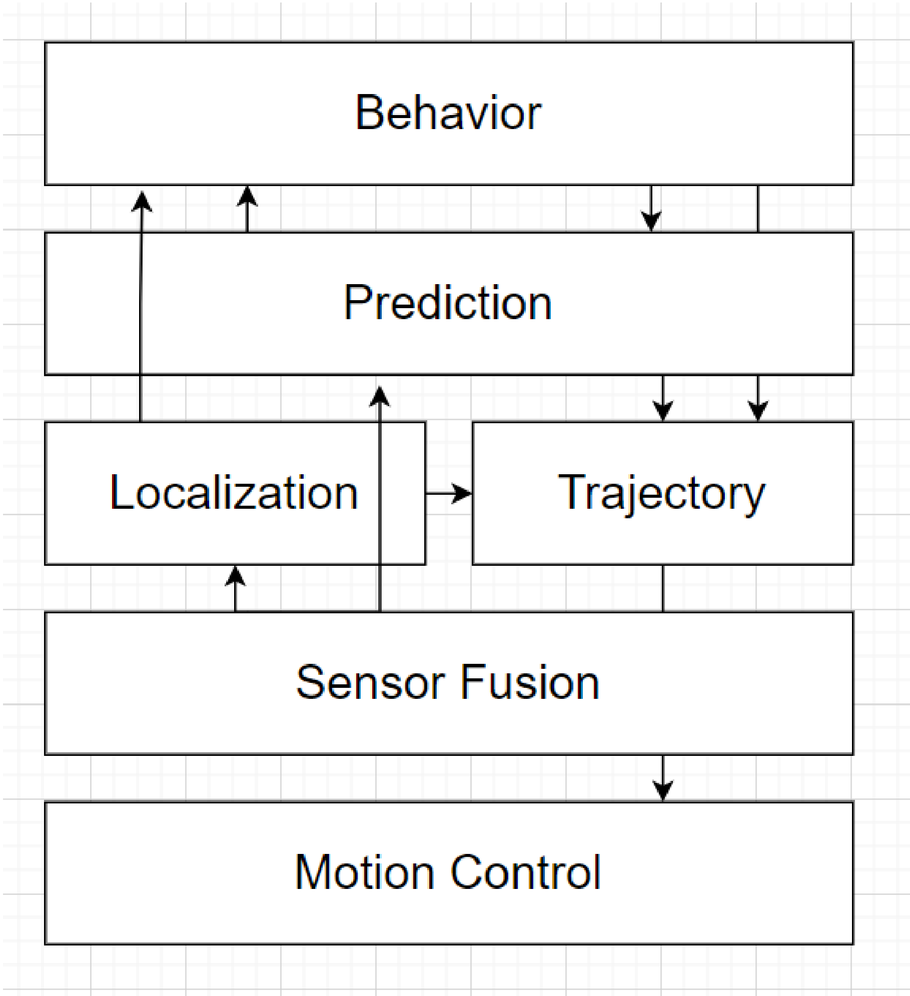
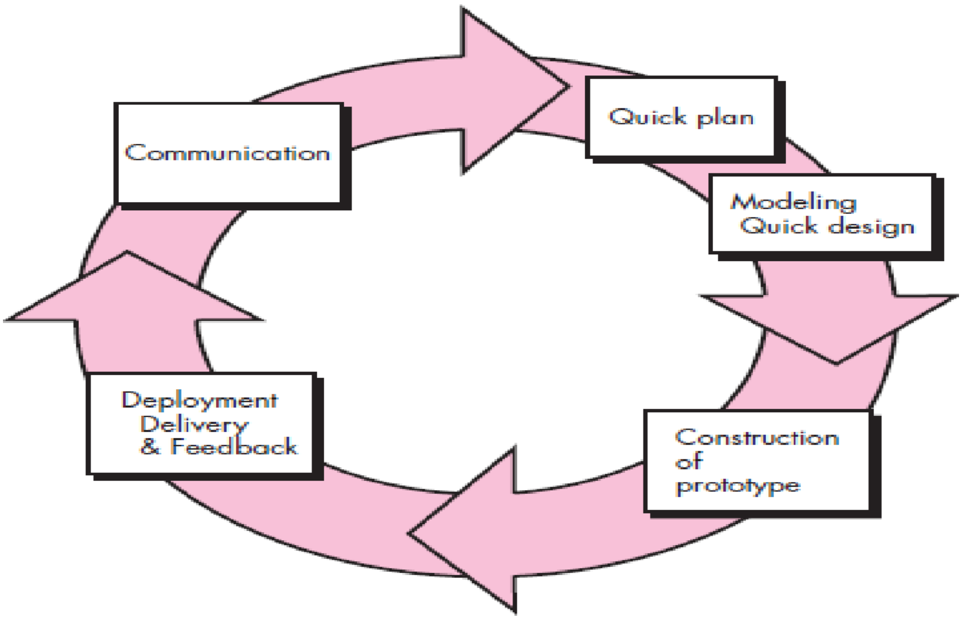


Fig 3: Methodology Used



DESIGN SPECIFICATIONS

4.1 System Architecture

Website consists of following components:

Registration:

- Register using valid email.
- Email verification.
- Successful login

Online Booking:

- opens the cab book tab
- fills the required details

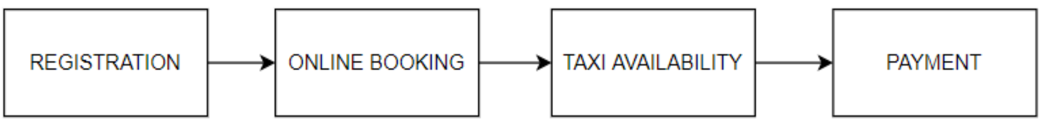
Taxi Availability:

- Bill button will show an alert of availability as well as distance and cost of trip
- Customer then confirms the order

Payment:

- All the autonomous cabs would be equipped with a QR code scanner using which user can do the payment after or during the ride.

Fig 4: Website Architecture



4.2 Design Level Diagrams

4.2.1 Component Design Diagrams

Fig 5: Component Design Diagram

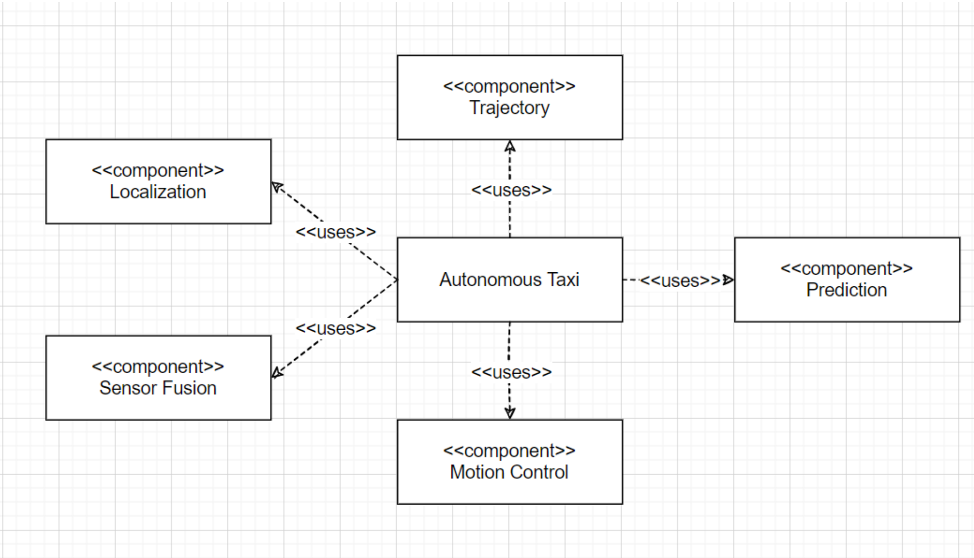
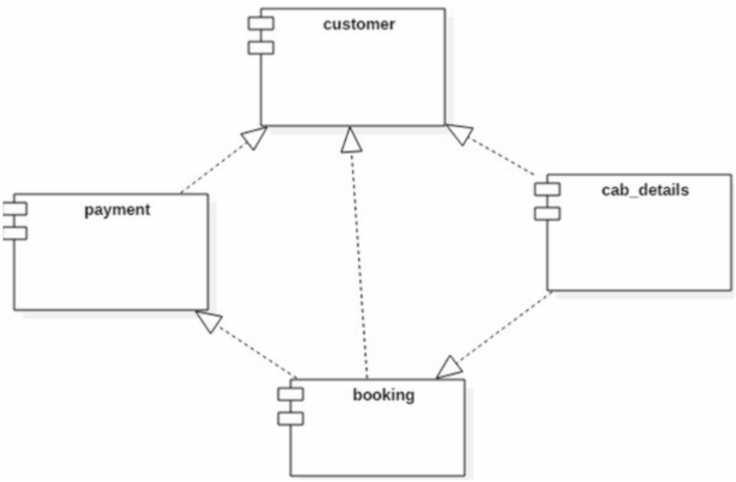
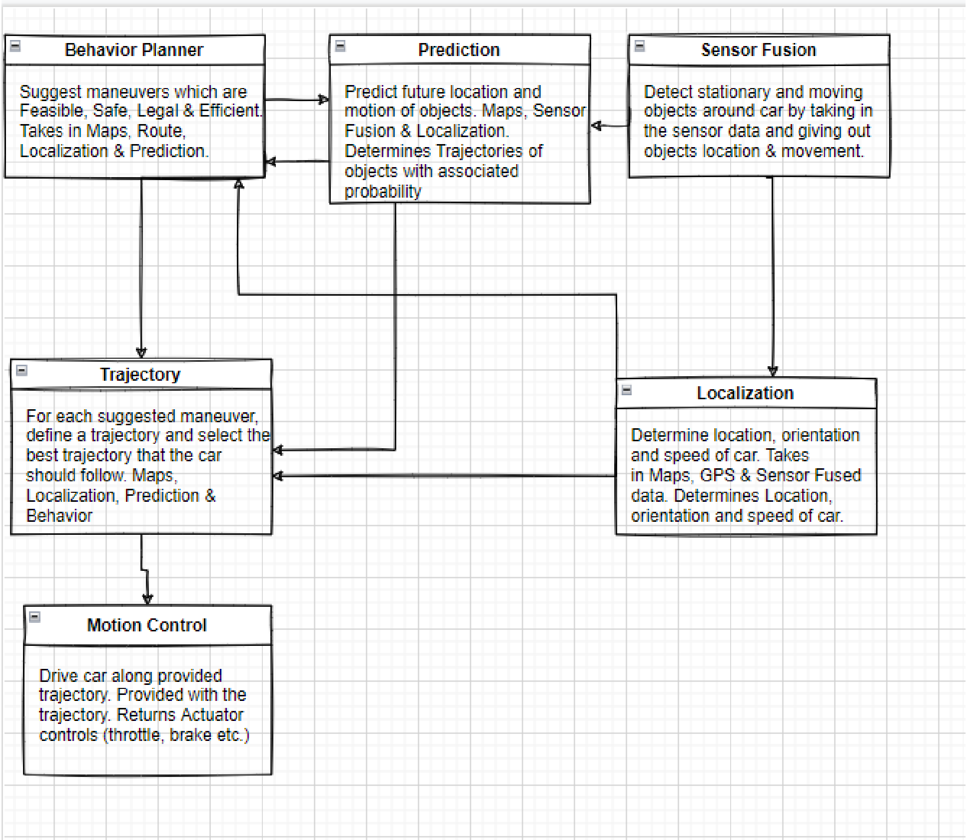


Fig 6: Component Design Diagram



4.2.2 Data Design Diagram

Fig 7: Data Design Diagram



4.2.3 State Chart Diagram

Fig 8: State Chart Diagram

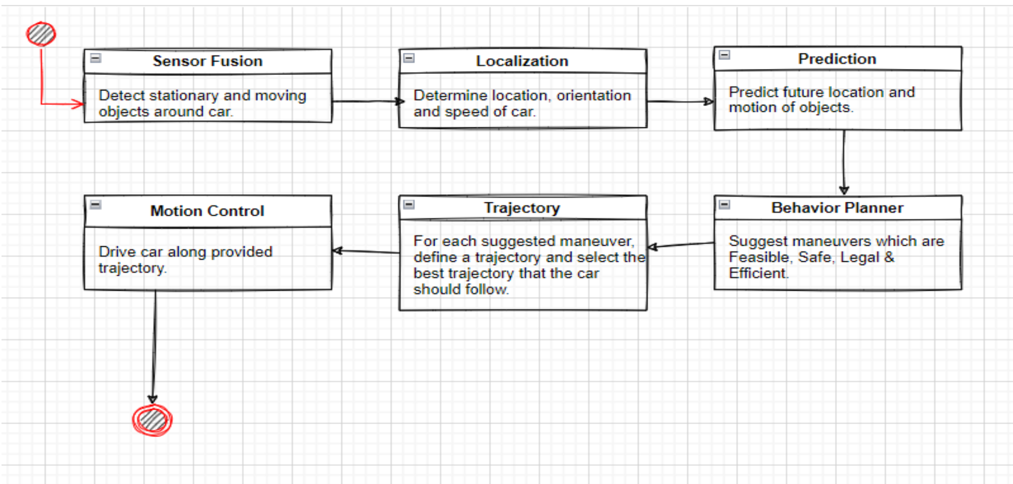


Fig 9: Registration

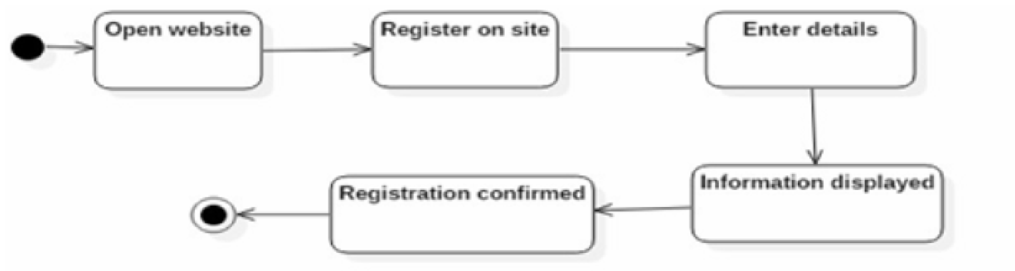
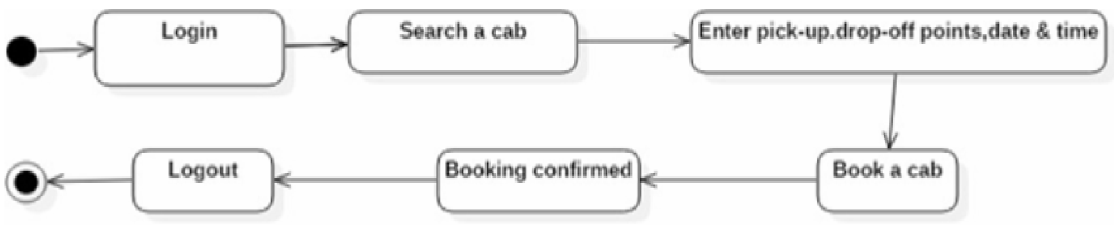


Fig 10: Booking of Cab



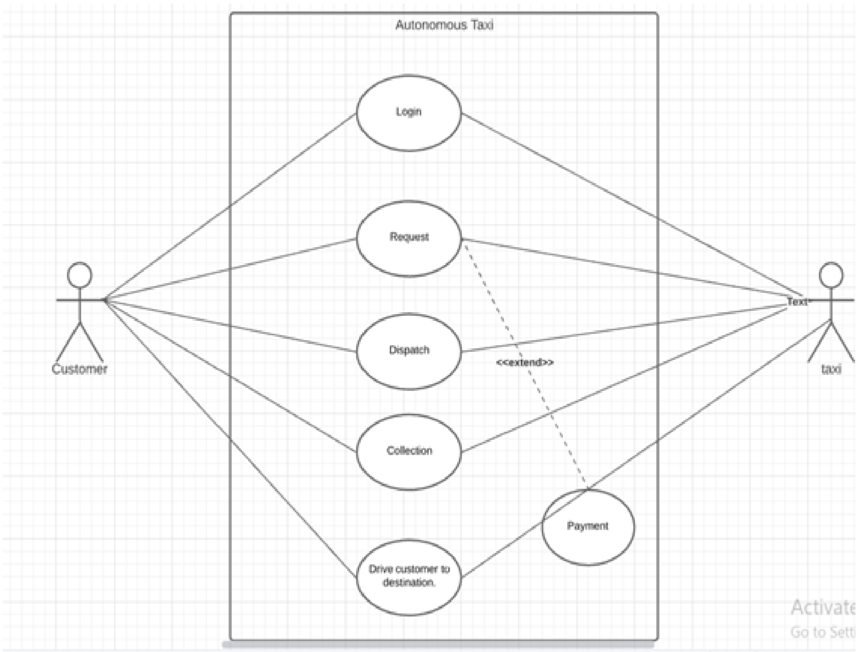
4.3 User Interface Diagram

4.3.1 Use Case Diagrams

4.3.1.1 Normal Scenario

Here we are discussing the basics of the project i.e. what is the desired outcome of the project.

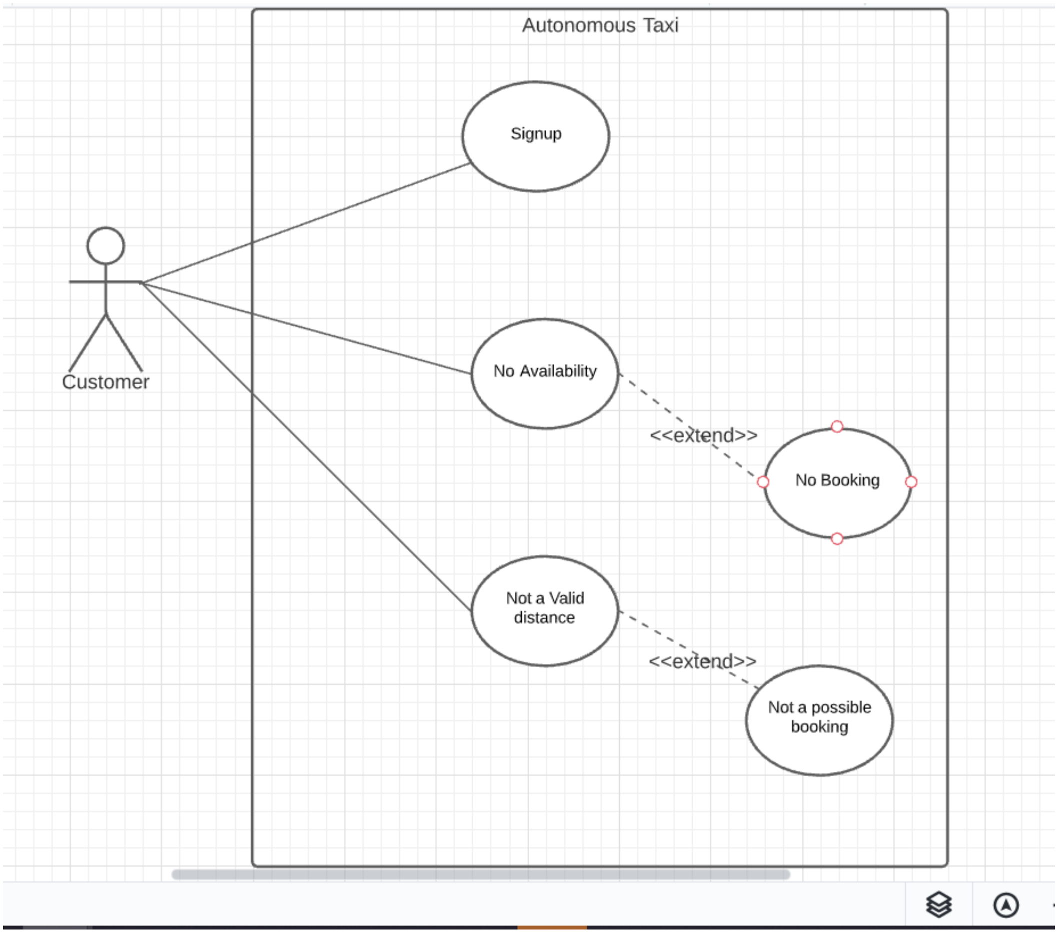
Fig 11: Normal Scenario



4.3.1.2 Alternate Scenario

Here we are discussing the possible if's and but's of the project i.e. how the system will deviate in case favorable conditions are not given.Only a few have been discussed over here while the thought process is in progress for the same.

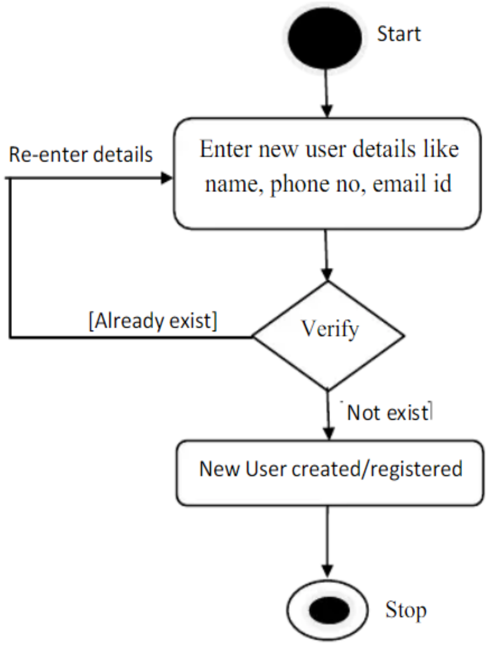
Fig 12: Alternate Scenario



4.3.2 Activity Diagram

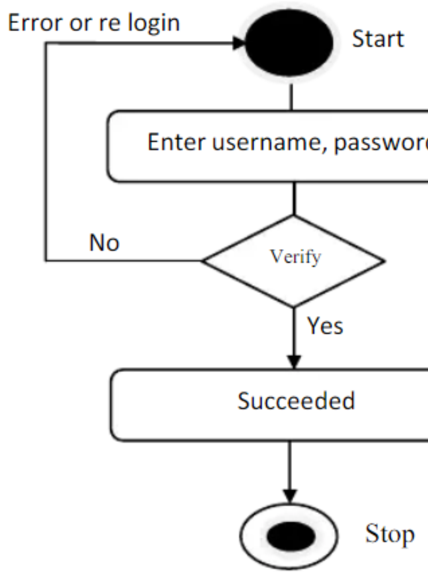
When the user tries to create a new account, they will have to enter details like their name, phone no. and email id. The app will verify if the user already exists or not. If the user already exists the app will direct it to the login/sign up page, else it'll create a new user.

Fig 13: Activity Diagram (Sign Up)



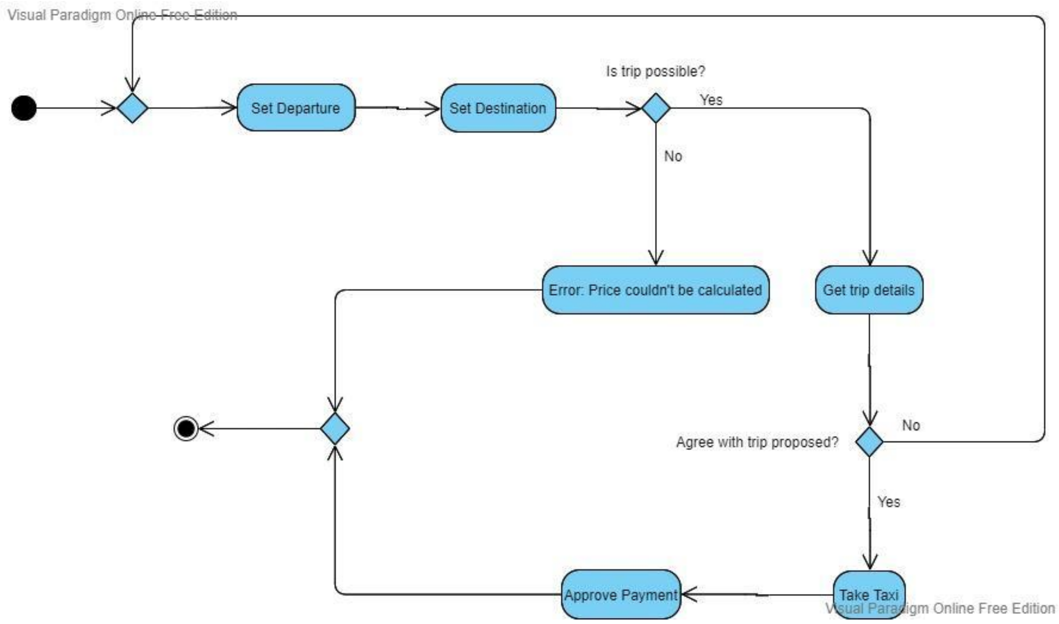
When the user tries to login, the app will ask them for their username and password. If verified that the user exists, the login will be successful else it will generate an error and send them back to the login/sign up page.

Fig 14: Activity Diagram (Login)



The user will set departure time followed by the destination. If the trip is possible, the app will generate the trip details which includes the payment and if the user agrees with the trip proposed, an option of “Take Taxi” will appear, after which the payment will be approved. If the trip isn’t possible, the app will ask the user to set the departure again.

Fig 15: Activity Diagram (Booking)



IMPLEMENTATION AND EXPERIMENTAL RESULTS

5.1 Experimental Setup

In this project, the experimental setup consisted of two parts, the simulator part, where we test our autonomous taxi in a simulated environment, and the website part, from where the taxi is booked. The simulated part of the project was done on the Udacity term 3 simulator. The simulator needed to be connected to the computer using WebSocket. The coding of the website was done on Visual Studio Code Editor and for testing Chrome browser was used.

5.2 Experimental Analysis

The experimental setup phases were analyzed at every step. The flow of data and the performance parameters were considered as major focus points of analysis.

5.2.1 Data

The path that our taxi travels is predefined and therefore the car's x position in map coordinates, car's y position in map coordinates, s position in frenet coordinates, d position in frenet coordinates, yaw angle in the map and car’s speed were stored in a .csv file and used to predict the next movement of the car.

Initially user details like email address, password are stored in the database. Also the user’s pickup and drop location is used to calculate an estimated fare for the cab ride.

5.2.2 Performance Parameters

The performance is analyzed throughout the experimentation process by focusing on how accurately it calculates the number of vehicles in the immediate vicinity, how smoothly it travels on the road and how fewer collisions the car avoids. The current model is accurate but its accuracy can be increased with further testing and debugging. The car will be judged on its response time.

For the website, the efficiency and performance parameters depend upon the internet connectivity and the system being used.

5.3 Working of the project

5.3.1 Procedural Workflow

Fig 16: Procedural Workflow

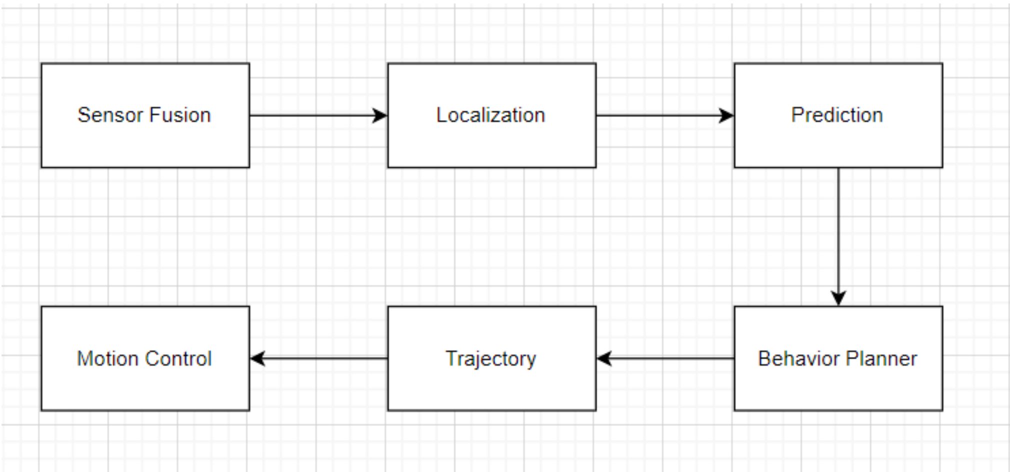
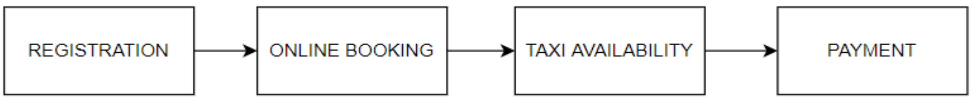


Fig 17: Procedural Workflow

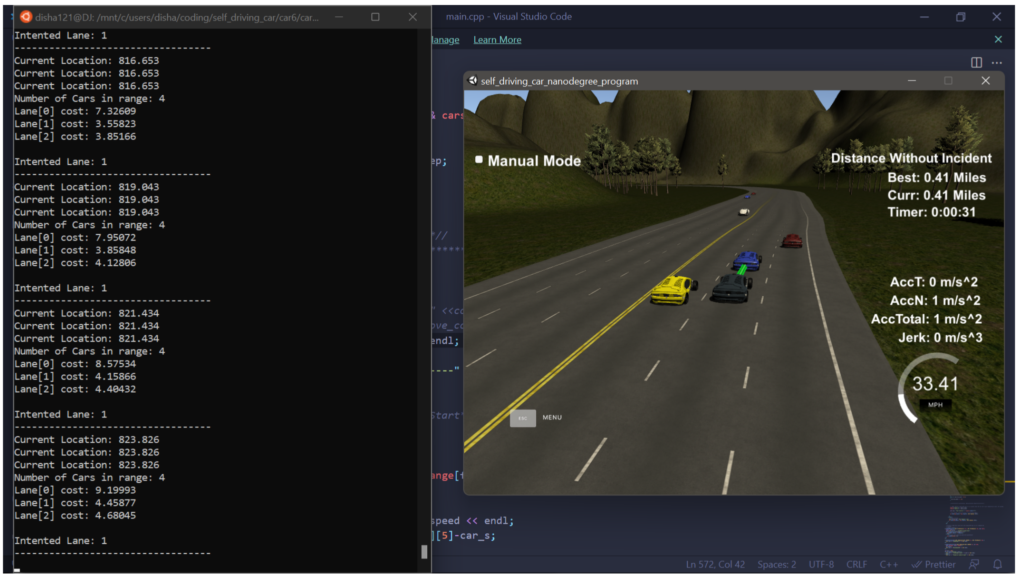


5.3.2 Algorithmic Approaches Used

The path for the car to travel on is predefined. A file containing the car's x position in map coordinates, car's y position in map coordinates, s position in frenet coordinates, d position in frenet coordinates, yaw angle in the map and car's speed is used to get the location every 0.02 second. The spacing between the x and y coordinates determine the speed of the car. We take the difference from the next point of the current point to decide the angle of the car in the upcoming second. The tangential and normal acceleration is measured as well as the jerk helps in deciding the total acceleration of the car. The simulator that we use has a constraint on the jerk. It cannot go over 10 m/s^2 as well as the acceleration, which cannot go over 50 m/s^2.

There is some latency between the simulator and the code that we pass on to with. During this delay the simulator will continue to use the points that it was last passed and therefore have a smooth transition. We will also store the previous coordinates for the same purpose. Polynomials are used to calculate the next x and y steps. With the help of the x and y coordinates along with the yaw angle, the process of predicting the succeeding route for the car will become easier.

Fig 18: Snapshot of Working Prototype



Lane Cost:

The system is developed on lane cost. There are 3 lanes on one side of our highway and if. The cost of each lane depends on two factors,

- Distance between the taxi and other vehicles.
- Speed of the other vehicle

Total cost of a vehicle = distance / speed.

More the distance and the speed of another vehicle, the better.

The lane with minimum lane cost is selected.

Fig 19: Snapshot of Output

```
Lane[0] cost: 6.91586
Lane[1] cost: 7.22078
Lane[2] cost: 3.61378

Intented Lane: 2
```

As can be seen from the above figure, lane cost for each lane is calculated and the lane with the minimum lane cost becomes the intended lane.

Vehicle Count:

While traveling in the real world, there are multiple vehicles traveling on the same road. And therefore the sensor fusion data also becomes crowded. We do not need to keep track of all the vehicles on the road, just the ones in the immediate vicinity will do. For our project we kept a track of vehicles 100m ahead of us and 10m behind us. The above image shows a tally of the number of vehicles in the immediate vicinity.

Fig 20: Snapshot of Output

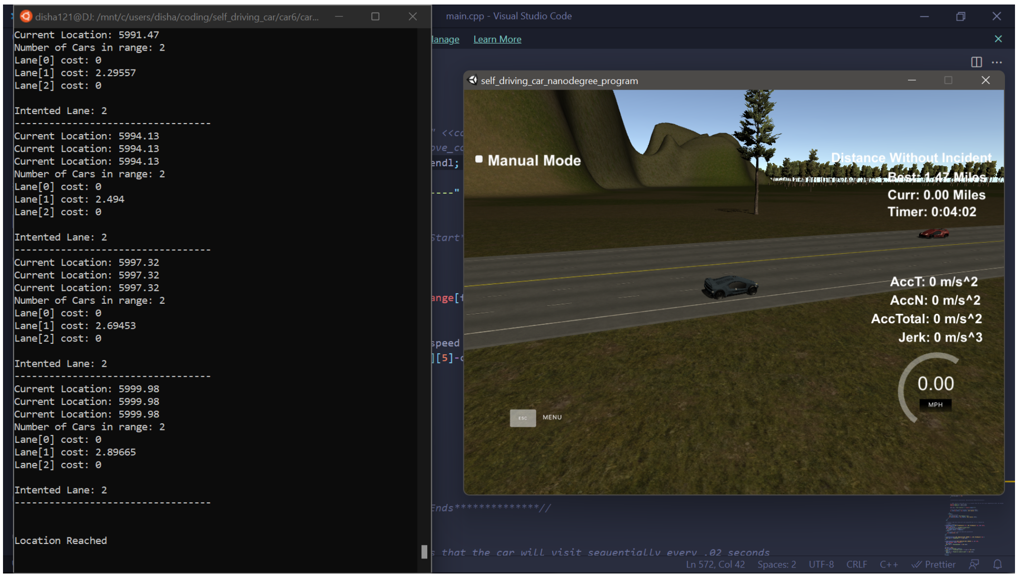
```
Number of Cars in range: 4
```

We also need to keep track of the lane of these vehicles.

Stopping at the destination:

The stopping and starting point for our taxi are predefined. When the destination point is reached the vehicle starts to slow down and then stops completely and waits there for a predefined period of time. After that the vehicle starts to slowly increase its speed until it is moving smoothly on the road. When it reaches the starting point again, the car stops moving and our task is finished.

Fig 21: Snapshot of Working Prototype



5.3.3 Project Deployment

The project can be deployed on a large scale in real life situations. Many major companies are designing their own self-driving cars and there are a lot of taxi booking systems available in the market. The combination of these two is not very far. This is an upcoming field which will be a revolution in the computer science industry. Our project is done using a simulator to simulate real life scenarios, although it doesn't consider all the problems that come with real life and only focuses on a few of them. This project can be deployed on a large scale with proper technology available.

5.3.4 System Screenshots

Fig 22: Snapshot of Working Prototype

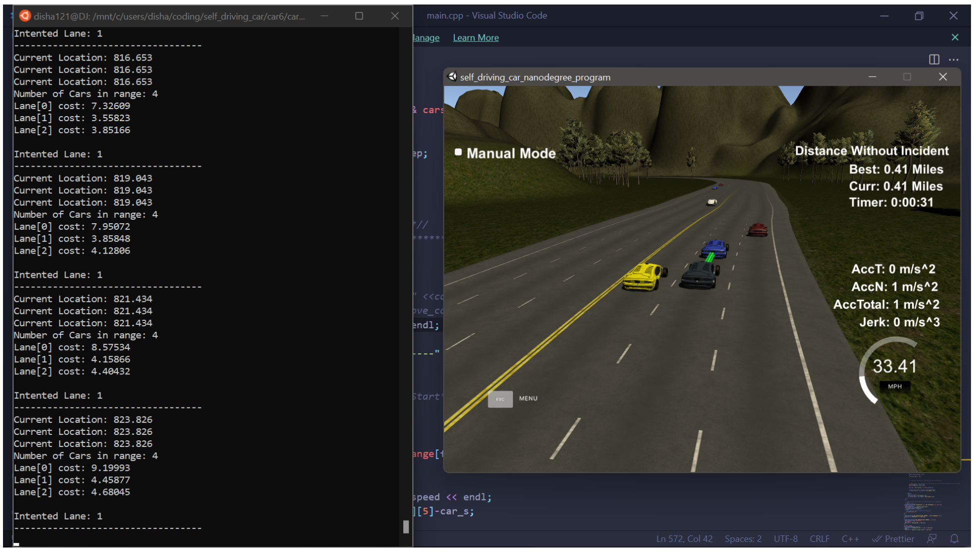


Fig 23: Snapshot of Working Prototype

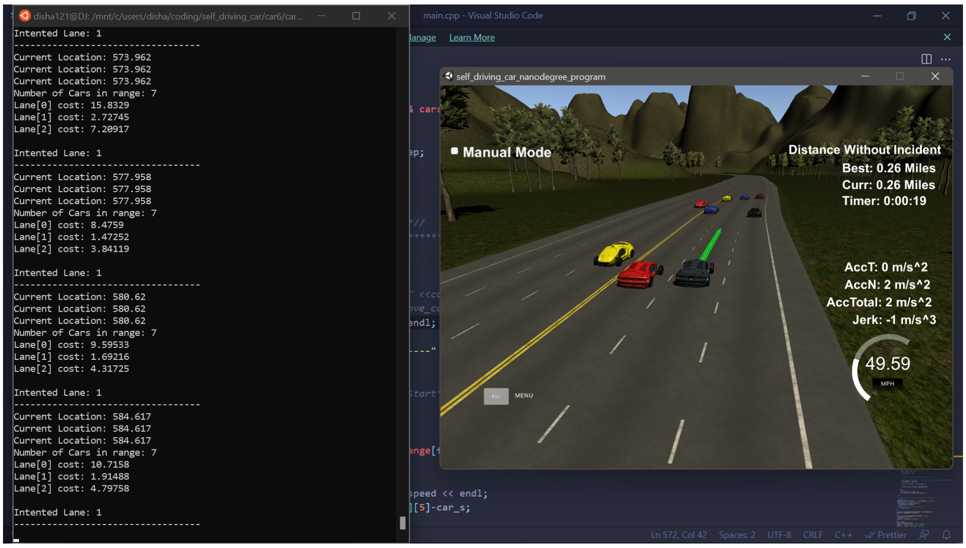


Fig 24: Snapshot of Working Prototype

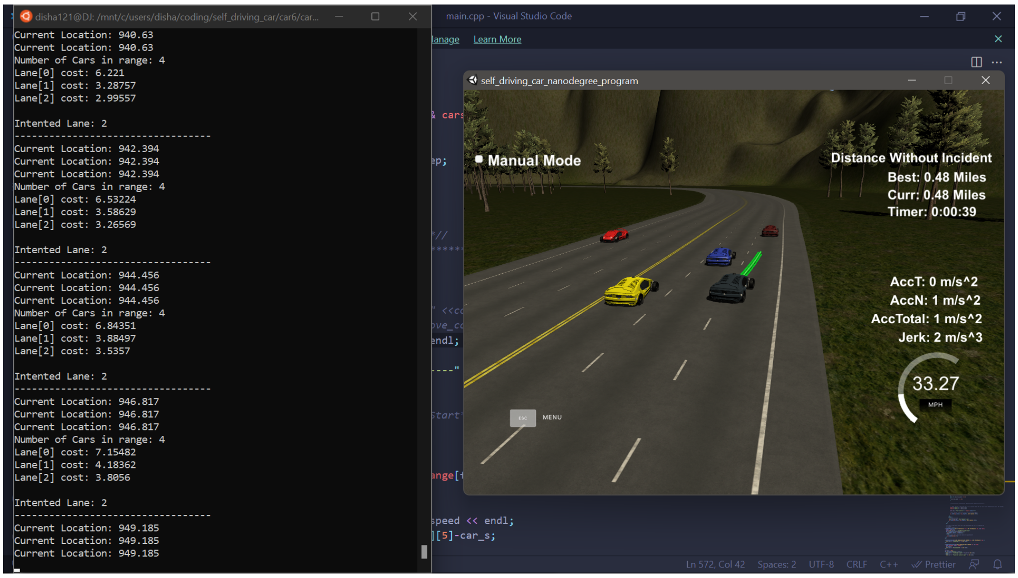
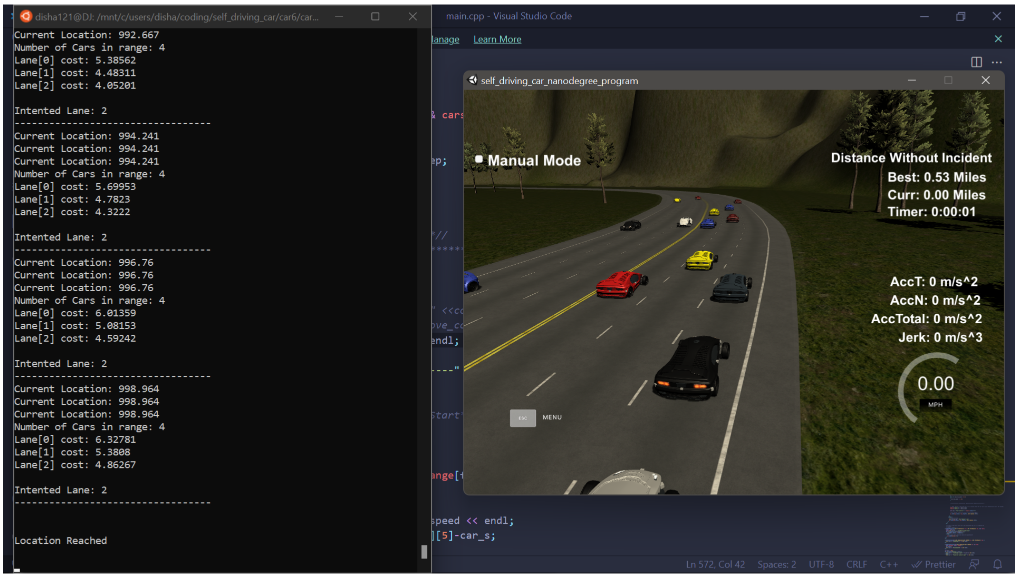


Fig 25: Snapshot of Working Prototype



Here are some of the snippets of the website made for users to book cabs.

Fig 26: Landing Page

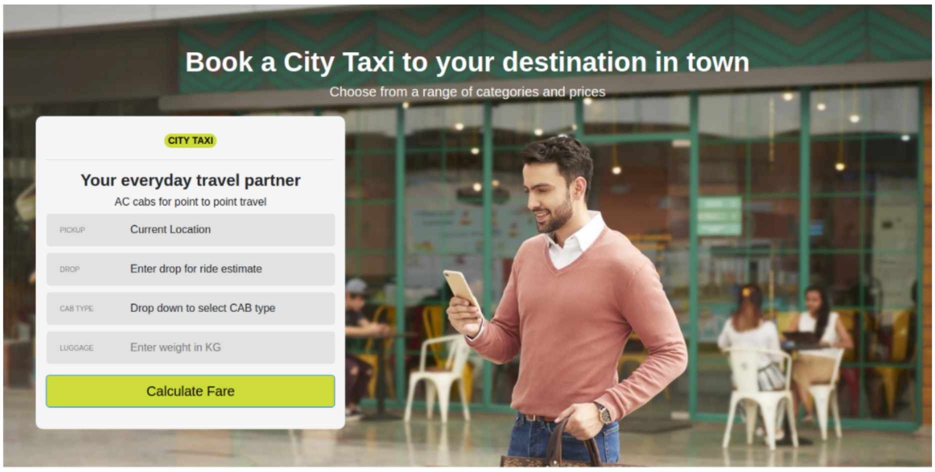


Fig 27: Login Page

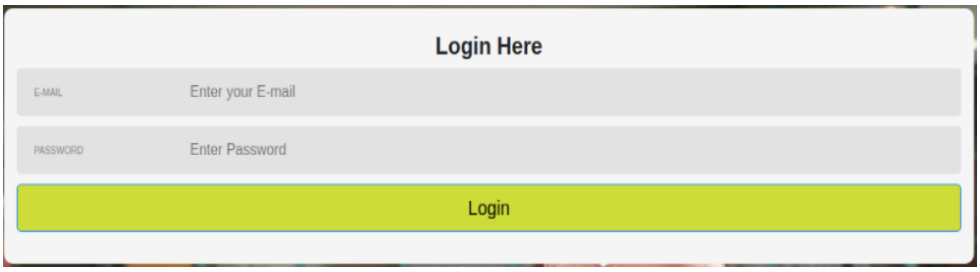


Fig 28: Signup Page

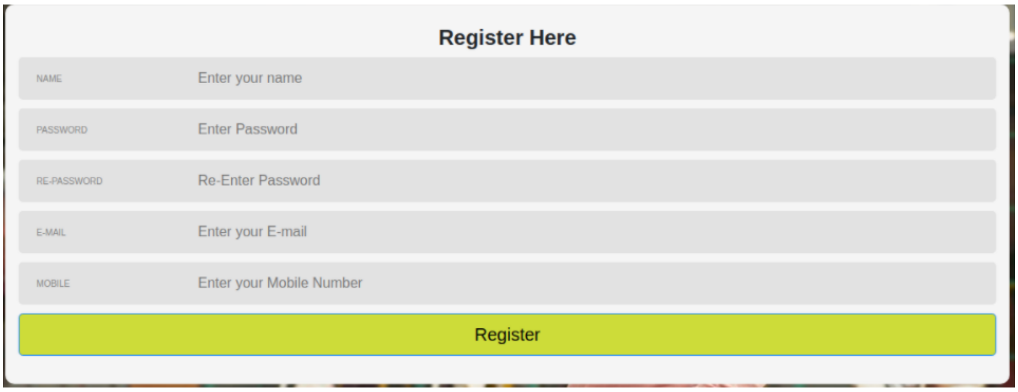
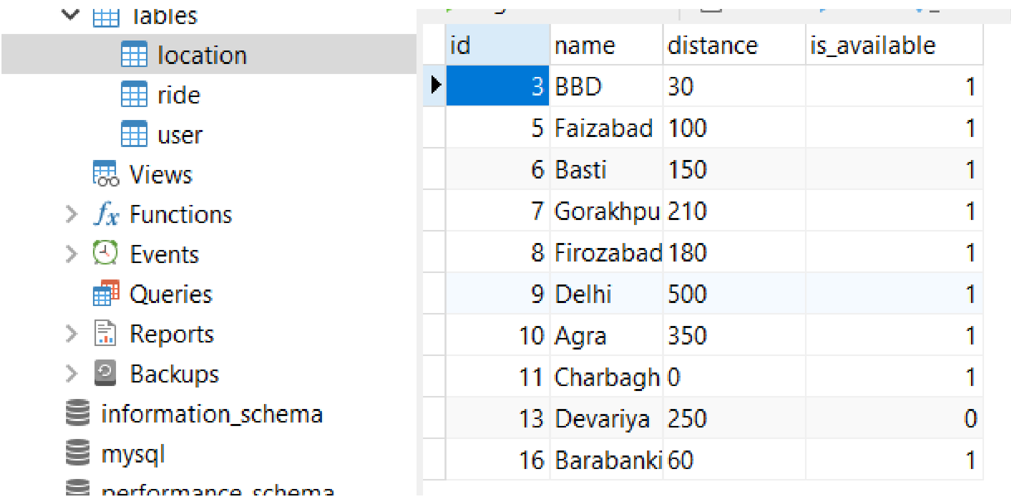
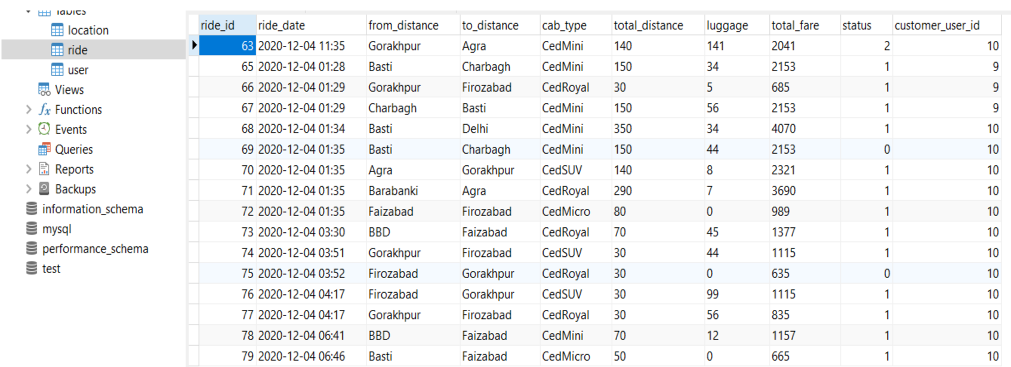


Fig 29: User Dashboard

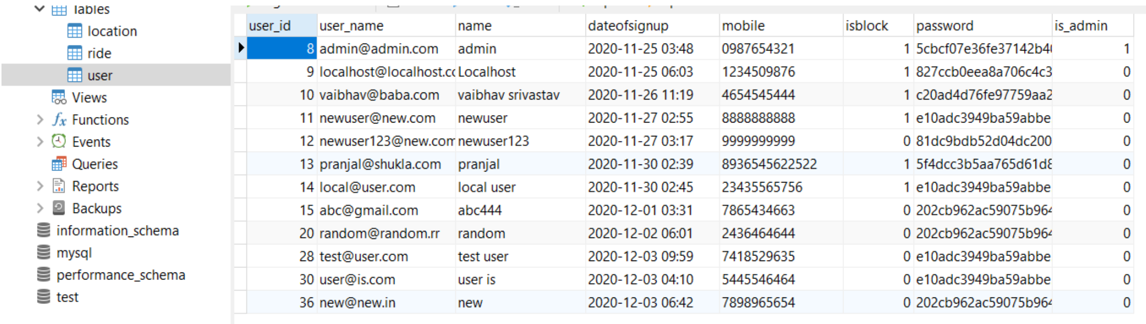
Fig 30: Database Tables



id	name	distance	is_available
3	BBD	30	1
5	Faizabad	100	1
6	Basti	150	1
7	Gorakhpu	210	1
8	Firozabad	180	1
9	Delhi	500	1
10	Agra	350	1
11	Charbagh	0	1
13	Devariya	250	0
16	Barabanki	60	1



ride_id	ride_date	from_distance	to_distance	cab_type	total_distance	luggage	total_fare	status	customer_user_id
63	2020-12-04 11:35	Gorakhpur	Agra	CedMini	140	141	2041	2	10
65	2020-12-04 01:28	Basti	Charbagh	CedMini	150	34	2153	1	9
66	2020-12-04 01:29	Gorakhpur	Firozabad	CedRoyal	30	5	685	1	9
67	2020-12-04 01:29	Charbagh	Basti	CedMini	150	56	2153	1	9
68	2020-12-04 01:34	Basti	Delhi	CedMini	350	34	4070	1	10
69	2020-12-04 01:35	Basti	Charbagh	CedMini	150	44	2153	0	10
70	2020-12-04 01:35	Agra	Gorakhpur	CedSUV	140	8	2321	1	10
71	2020-12-04 01:35	Barabanki	Agra	CedRoyal	290	7	3690	1	10
72	2020-12-04 01:35	Faizabad	Firozabad	CedMicro	80	0	989	1	10
73	2020-12-04 03:30	BBD	Faizabad	CedRoyal	70	45	1377	1	10
74	2020-12-04 03:51	Gorakhpur	Firozabad	CedSUV	30	44	1115	1	10
75	2020-12-04 03:52	Firozabad	Gorakhpur	CedRoyal	30	0	635	0	10
76	2020-12-04 04:17	Firozabad	Gorakhpur	CedSUV	30	99	1115	1	10
77	2020-12-04 04:17	Gorakhpur	Firozabad	CedRoyal	30	56	835	1	10
78	2020-12-04 06:41	BBD	Faizabad	CedMini	70	12	1157	1	10
79	2020-12-04 06:46	Basti	Faizabad	CedMicro	50	0	665	1	10



user_id	user_name	name	dateofsignup	mobile	isblock	password	is_admin
8	admin@admin.com	admin	2020-11-25 03:48	0987654321	1	5cbcf07e36fe37142b4	1
9	localhost@localhost.cc	Localhost	2020-11-25 06:03	1234509876	1	827ccb0eea8a706c4c3	0
10	vaibhav@baba.com	vaibhav srivastav	2020-11-26 11:19	4654545444	1	c20ad4d76fe97759aa2	0
11	newuser@new.com	newuser	2020-11-27 02:55	8888888888	1	e10adc3949ba59abbe	0
12	newuser123@new.com	newuser123	2020-11-27 03:17	9999999999	0	81dc9bdb52d04dc200	0
13	pranjal@shukla.com	pranjal	2020-11-30 02:39	8936545622522	1	5f4dcc3b5aa765d61d8	0
14	local@user.com	local user	2020-11-30 02:45	23435565756	1	e10adc3949ba59abbe	0
15	abc@gmail.com	abc444	2020-12-01 03:31	7865434663	0	202cb962ac59075b964	0
20	random@random.rr	random	2020-12-02 06:01	2436464644	0	202cb962ac59075b964	0
28	test@user.com	test user	2020-12-03 09:59	7418529635	0	e10adc3949ba59abbe	0
30	user@is.com	user is	2020-12-03 04:10	5445546464	0	e10adc3949ba59abbe	0
36	new@new.in	new	2020-12-03 06:42	7898965654	0	202cb962ac59075b964	0

5.4 Testing Process

5.4.1 Test Plan

The testing of the simulator and the website are done separately.

5.4.2 Features to be tested

- Changing lanes according to the lane cost
- Maintain minimum jerk and acceleration
- User Identification in website
- Booking identification

5.4.3 Test Strategy

For the simulator, test strategy includes testing various modules separately and then testing them together. It helps us to decide which part of the code is causing the problem.

The goals of system testing are to detect faults that can only be exposed by testing the entire integrated system or some major part of it. Generally, system testing is mainly concerned with areas such as performance, security, validation, load/stress, and configuration sensitivity. But in our case well focus only on function validation

5.4.4 Test Techniques

- Simulator testing is done by running sample inputs and matching the results with desired results.

- Website testing is done by running sample inputs and matching the results with desired results.In this report all the possible combinations are shown in tables as follows.

5.4.5 Test Cases

- For the simulator, the first test to change lanes, we first try to change the lane immediately after finding the minimum lane cost.

Fig 31: Snapshot of Working Prototype

Fig 32: Snapshot of Working Prototype

- The second test case to change lanes is to take a mean of the current lane cost and the new lane cost for every 10 frames.

Fig 33: Snapshot of Working Prototype

Table 4: Login Test Case

Condition	**Email id**	**Password**	**Action (Expected result)**
C1.	Yes	Yes	Correct
C2.	Yes	No	Incorrect
C3.	No	Yes	Incorrect
C4	No	No	Incorrect

Table 5: Registration Test Case

Condition	**Name**	**Email id**	**Password**	**Confirm password**	**Mobile**	**Action (Expected result)**
C1.	Yes	Yes	Yes	Yes	Yes	Correct
C2.	Yes	Yes	Yes	Yes	No	Incorrect
C3.	Yes	Yes	Yes	No	Yes	Incorrect
C4.	Yes	Yes	No	Yes	Yes	Incorrect
C5.	Yes	No	Yes	Yes	Yes	Incorrect
C6.	Yes	Yes	Yes	Yes	Yes	Incorrect
C7.	No	Yes	Yes	Yes	Yes	Incorrect
….	..…	…..	…..	……	…..	….
C62.	No	No	No	No	No	Incorrect
C63.	Yes	No	No	No	No	Incorrect
C64:	No	No	No	No	No	Incorrect

5.4.6 Test Results

- The car experiences sudden jerks, accelerations and collisions when the lane is changed every frame after calculation.
- The car moves smoothly onto the next lane when lane cost is calculated and taken the mean of every 10 frames.

5.5 Results and Discussions

- For the simulator, the results were positive and the car runs smoothly, changes lanes without any sudden movements and collisions. Users can successfully take the taxi and not worry about sudden collisions and car jerks.
- Correct Email Id and password:Successful login
- Incorrect Id or password: Failure message
- Correct location inputs,cab type and luggage weight:Successful booking

5.6 Inferences Drawn

- The taxi runs fine in the environment even when there are a lot of cars present.
- The taxi was able to smoothly move on its trajectory without any sudden jerks and accelerations.
- The taxi changes lanes successfully.
- Code to run the taxi runs perfectly.
- There is a little jerk when the car stops at its location.
- So the website works well with the help of correct input values.

5.7 Validation of Objectives

Table 6: Validation of Objectives

Sr. No.	**Objective**	**Status**
1.	Smoothly drive on road	Successful
2.	Change lanes	Successful
3.	Collision avoidance	Successful
4.	Connect to the website.	Unsuccessful

CONCLUSIONS AND FUTURE SCOPE

6.1 Conclusion

Car Model: Our aim was to make a taxi which can smoothly move on its trajectory, change lanes with minimum jerk and acceleration and avoid collisions. During the implementation of our prototype we realized that our idea is implementable and can save a lot of time and energy. In the initial stages of our project, we learnt how to process images and how CNN models work and later on we realized that we need a different type of model for what we have in mind and therefore moved onto another concept of self driving cars that is path planning, and that is what we implemented in our final prototype.

Website: Our aim was to provide users with an interface using which they can check the availability of cabs and to be able to book cabs. Since we were not very proficient with the technologies of Web Development, initially we had to spend a lot of time learning them. After this we were able to implement the code of the website.

6.2 Environmental/Economical/Social Benefits

Environmental Benefits: Environment plays a major role for the sustenance of living beings. Humans have for a long time not cared about the environment and have been exploiting the natural resources recklessly and as result the atmosphere is getting largely polluted. It is very important to work upon the projects that bring about sustainable development and will be beneficial for the environment. Autonomous Cars are a solution for the growing congestion on the roads which will help minimize the air pollution. It will also help to reduce the energy consumption with efficient working of the cars hence reducing the dependence on non-conventional energy resources.

Economic Benefit: The primary benefit in terms of finances will be to the taxi operators who can now cut-down their cost of labor which will lead to increase in their profit margin.

Social Benefit: With the advancement of autonomous technology in the sector of the transport industry,safe travel will be realized as the task to be performed by humans will now be done by machines hence reducing the rate of errors as well as risks.Also,it will bring down the count of accidents that occur every year to a great extent making the road a safer option for people.

6.3 Reflections

We tried to run our taxi from the keyboard. Our taxi is able to smoothly move on its trajectory, change lanes with minimum jerk and acceleration and avoid collisions.

6.4 Future Work Plan

We plan to improve our project's accuracy and also implement the remaining objectives that have not been achieved till now. After implementing all the objectives of the project and removing all the bugs that occur and having a finer movement of the taxi we can expand our autonomous taxi project with multiple vehicles as well as more than one location.

PROJECT METRICS

7.1 Challenges Faced

While implementing the project, the group faces a large number of challenges such as:

- Figuring out how the simulator works.
- Testing different simulators and deciding which is the most feasible for our situation.
- Testing different ways to train an autonomous car and figuring out which one will work for our situation.
- How to make the taxi stop at different destinations.
- Learning the technologies used for Web Development.
- Connecting the code to the simulator.

7.2 Relevant Subjects

Table 7: Course Subjects

Subject Name	Description
Software Engineering	Used the concepts of Software Engineering for requirement analysis, testing, designing and planning of project
Machine Learning	Learned basic model training methods for training the model for self driving cars.
Computer Programming	Learned the process of programming and logic building that is used during the coding .
Database Management System	Learned about storing and retrieving user's data and the techniques to manipulate databases which is required during the coding phase.

Data Structures	Learned about important data structures and their applications which would be helpful in development of the app.

7.3 Interdisciplinary Knowledge Sharing

Our project ‘Autonomous Taxi’ involves knowledge from diverse fields of engineering. It involves a variety of disciplinary knowledge from Computer engineering and various concepts of it. The knowledge of all the branches was very essential for the implementation of this project.

7.4 Peer Assessment Matrix

Table 8: Peer Assessment Matrix

		Evaluation of:			
		Harsimranjot	Disha	Prerna	Navleen
Evaluation By:	Harsimranjot	5	5	5	5
	Disha	5	5	5	5
	Prerna	5	5	5	5
	Navleen	5	5	5	5

7.5 Role Playing And Work Schedule

Harsimranjot (101803224)

Worked on the software part of the project. Developed a full stack website using which users can book their cab as per their requirements.

Disha Jindal (101803330)

Work with the simulator. Create a logic to stop and start the taxi, switching lanes and making sure that the taxi travels on the road by maximum avoidance of collisions.

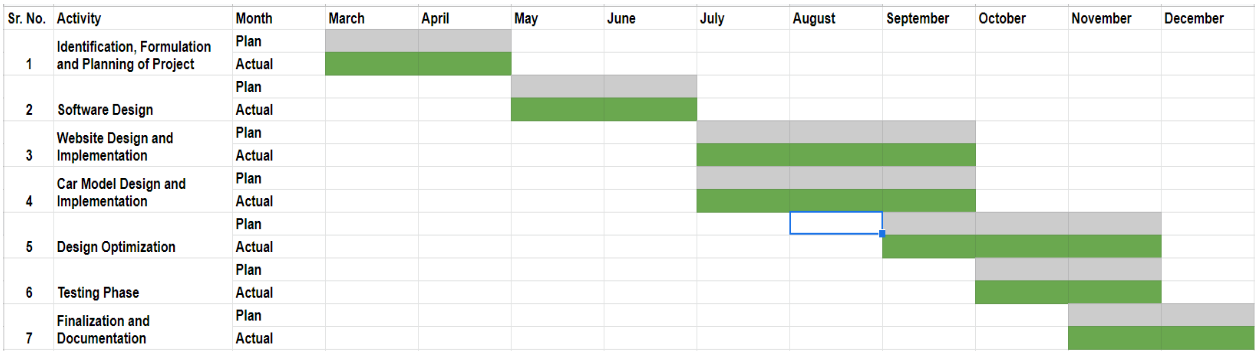
Prerna Puri (10180332)

Worked on the software part of the project. Developed a full stack website using which users can book their cab as per their requirements.

Navleen Kaur (101853032)

Work with the simulator. Create a logic to stop and start the taxi, switching lanes and making sure that the taxi travels on the road by maximum avoidance of collisions.

Fig 34: Gantt Chart



7.6 Student Outcomes(A-K mapping)

Table 9: Student Outcomes

S. no.	Description	Outcome
A1	Applying mathematical concepts to obtain analytical and numerical solutions.	Applied mathematical concepts to obtain analytical and numerical solutions
A2	Applying engineering techniques for solving computing problems.	Applied engineering techniques such as programming for solving computing problems.
B1	Identify the constraints, assumptions and models for the problems.	Stated the constraints as well as the assumptions for the problem
B2	Use appropriate methods, tools and techniques for data collection.	Collected data using appropriate techniques
B3	Analyze and interpret results with respect to assumptions, constraints and theory.	Analyzed and interpreted the results with respect to assumptions, constraints and theory.
C1	Design software systems to address desired needs in different problem domains.	Designed the specified software system to fit the needs, such as the model
C2	Can understand scope and constraints such as economic, environmental, social, political, ethical, health and safety,manufacturability, and sustainability.	Designed the project keeping in mind the aforementioned constraints and developed with the need to improve environment and social upliftment.
D1	Fulfill assigned responsibility in	Fulfilled the assigned responsibility by dividing the work properly and

	multidisciplinary teams.	carrying it out in teams.
D2	Can play different roles as a team player.	Played different roles as a team member
E1	Identify engineering problems.	Clearly identified engineering problems
E2	Develop appropriate models to formulate solutions.	Formulated practical solutions to rectify the identified problems.
E3	Use analytical and computational methods to obtain solutions.	We were able to obtain solutions using experimental and investigative techniques.
F1	Showcase professional responsibility while interacting with peers and professional communities.	Showed professional responsibility while interacting with others.
F2	Able to evaluate the ethical dimensions of a problem.	We were able to evaluate ethical dimensions of a problem
G1	Produce a variety of documents such as laboratory or project reports using appropriate formats.	Produced the required documents from time to time.
G2	Deliver well-organized and effective oral presentations.	Delivered effective oral presentations
H1	Aware of the environmental and societal impact of engineering solutions.	Yes, our project was developed by considering both the aspects
H2	Examine economic trade offs in computing systems.	Examined economic tradeoffs in computing systems.

I1	Able to explore and utilize resources to enhance self-learning.	We were able to achieve it by team coordination and interdisciplinary knowledge gathering
I2	Recognize the importance of life-long learning.	It was one of the important learnings from the capstone project.
J1	Comprehend the importance of contemporary issues.	We reviewed a variety of issues for our project development and it made us more aware of such issues.
K1	Write code in different programming	Wrote codes different languages and platforms
K2	Apply different data structures and algorithmic techniques.	Applied different techniques studied in our course.
K3	Use software tools necessary for computer engineering domain	Applied and used different software tools.

7.7 Brief Analytical Assessment

Q1. What source of information did your team explore to arrive at the list of possible project problems?

Ans: The group had a clear understanding of the Capstone Requirement and some of the problems that need to be explored. We explored over internet over some field that can be explored or that can be the future.

Q2. What analytical, computational and/or experimental methods did your project team use to obtain solutions to the problems in the project?

Ans: Our team used a hit and trial method to find the perfect combination for website and car model. On the car model side of things, first we tried a cnn model and then moved to path planning.

Q3. Did the project demand demonstration of knowledge of fundamentals, scientific and/or engineering principles? If yes, how did you apply?

Ans: Yes, the project did demand demonstration of knowledge of fundamentals, scientific and engineering principles. For our website we created a database which used the concepts of dbms. We also used various programming concepts and they were enhanced further with the help of this project. New techniques were learnt and applied.

Q4. How did your team share responsibility and communicate the information of schedule with others in a team to coordinate design and manufacturing dependencies?

Ans: Our team consisted of four members. We divided the project into subtasks, each individual carrying out specific tasks and helping out each in the processes. Information was communicated via Whatsapp and Zoom meetings.

Q5. What resources did you use to learn new materials not taught in class for the course of the project?

Ans: We took the help from online resources. Also we took the help of various blogs and research papers in order to get knowledge to carry out our project.

Q6. Does the project make you appreciate the need to solve problems in real life using engineering and could the project development make you proficient with software development tools and environments?

Ans: The project made us appreciate the need to solve problems in real life using engineering because during the initial stages we did get to learn a lot of new things that could be implemented in real life and can make life easier for everyone, and thus help the human kind. This project taught us a lot about new technologies and software engineering thereby making us proficient in the same.

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PLAGIARISM REPORT

Fig 35: Snapshot of Plagiarism Report

	Title	State	Similarity	Report	Submit Date	
	Autonomous Taxi	Completed	10%	View Report	2021-12-17 14:26	