Naturalistic driving simulation

by Subhashini J

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NATURALISTIC DRIVING SIMULATION USING AUTOMATION

A PROJECT REPORT

Submitted by

LEELA GUNA KRISHNA KOMPALLI [Reg No:RA1611004010191]
ROHAN ARYA [Reg No:RA1611004010806]
GAURAV KHANNA [Reg No:RA1611004010826]
RAHUL GUPTA [Reg No:RA1611004010834]

Under the guidance of
Dr. J. SUBHASHINI
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SRM UNIVERSITY

(Under Section 3 of UGC Act, 1956)

BONAFIDE CERTIFICATE

Certified that this project report titled "**NATURALISTIC DRIVING SIMULATION USING AUTOMATION**" is the bonafide work of **"LEELA GUNA KRISHNA KO MPALLI [Reg No:RA1611004010191], ROHAN ARYA [RegNo:RA16110 040108 06], GAURAV KHANNA [Reg No:RA1611004010826], RAHUL GUPTA [RegNo :RA16 11004010834]**", who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE

Dr. J. SUBHASHINI
GUIDE
Assistant Professor
Dept. of electronics and communication engineering

SIGNATURE

Dr. T. Rama Rao
HEAD OF THE DEPARTMENT
Dept. of electronics and communication Engineering

Signature of the Internal Examiner

Signature of the External Examiner

ABSTRACT

The automobile industry has been finding ways to make driving safer and more convenient.We have reached a point where we need to automate the process of driving and make it more affordable. The present implementations are very robotic and cannot run among human driven vehicles, this made us realise the need of having a more naturalistic driving style for the autonomous vehicles. This research paper focuses on making a level 3 autonomous vehicle with the help of computer vision and deep learning. The main objective is to achieve the most ideal results in lane detection and object detection which can be worked upon to improve results. The reason that this project is of such great value is the fact that 80%of road accidents happen due to human error and negligence and we believe that providing a driver aid of some sorts could be really helpful in such scenarios With the help of this paper we will be able to obtain high values with great accuracy with the help of which this can be implemented in real time vehicles by just making a few alterations and by simple calibrations. We believe this will be a step towards a complete autonomous future.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my guide, Dr J.SUBHASHINI for her valuable guidance, consistent encouragement, personal caring, timely help and providing me with an excellent atmosphere for doing research. All through the work, in spite of his busy schedule, she has extended cheerful and cordial support to me for completing this research work.

Leela Guna Krishna Kompalli[Reg No:RA1611004010191]

Rohan Arya[Reg No:RA1611004010806]

Gaurav Khanna[Reg No:RA1611004010826]

Rahul Gupta[Reg No:RA1611004010834]

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CHAPTER 1

INTRODUCTION

Naturalistic driving is the way we are able to train the vehicle to drive in a human-like fashion as any vehicle being built has to be driven in a sea of other vehicles. Self-driving vehicles have been a constantly evolving subject and have 5 levels depending on the dependability and human inputs needed. The 1st level is when the car can either control the speed or the steering angle, an example of this is the cruise controls present in vehicles. The 2nd level of autonomy is meant to handle both steering angles and braking for the vehicle. The 3rd level allows the user to take his eyes off the road but needs to be mentally aware of the surroundings. The 4th level is a self-dependent system where the user input isn't needed for most of the journey. Level 5 is a completely automated system and doesn't need any human even be present in the vehicle. The history of autonomous cars dates back to 1939 which was an electric vehicle guided with the help of radio-controlled electromagnetic field which was guided with the help of magnetized metal spikes which was later improved upon with a camera based system in 1977 by the Japanese but was flawed due to the lack of resources at that time. The mainstream market today provides level 1 autonomy in the help of assistive parking and braking systems or adaptive cruise control. Companies like Tesla were able to achieve level 2 of autonomy and are on the way to achieve level 3. Level 4 and 5 is yet to be introduced by manufacturers as the data set needed to train the vehicle is insufficient at this moment and people are not very supportive of the technology as we end up giving too much control to technology, it is very easy to differentiate between a car driven by a human compared to a car be autonomously driven and this is the biggest flaw due to which we haven't reached a fully autonomous system. The project can be simulated on various Open Source Simulators such as udacity autonomous simulator, Carla simulator, lgslv simulator, etc. In our project we have used Udacity autonomous simulator for lane detection and path following, and Carla for object detection (vehicles, pedestrians and traffic lights). We have used the OpenCV library in order to perform the desired tasks. We have used Canny Edge Detection and Hough Transformation to detect the edges and the boundary lines. Carla uses the same feature as mentioned above. The object detection part is done in Carla sim. We have made a data-set consisting of required objects to detect and trained it (including traffic lights). For a much faster detector, "YOLO" can be used which requires a huge amount of processing power.

CHAPTER 2

LITERATURE SURVEY

[1] V. Shankar, P. Jovanis, J. Aguero-Valverde, and F. Gross, “Analysis of naturalistic driving data: prospective view on methodological paradigms,” Transportation Research Record: Journal of the Transportation Research Board, no. 2061,pp. 1–8, 2008.

The paper(Shankar et al., 2008)focuses on the prediction of crashes so we can prevent them when we have a large data set to predict the chance of crashes it is easier to reach for the vehicle compared to the immediate response of the vehicle which is too late to react sometimes. This method is a better approach as the chance of preventing the accident is much higher.

[2] S. G. Klauer, T. A. Dingus, V. L. Neale, J. D. Sudweeks, D. J. Ramsey et al., “The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data,” 2006.

This paperKlauer et al. (2006)is a study to better understand the reason for accidents occur it took a data set dealing with 3 types of drivers and after the study, they realized that most of the accidents occur because of human negligence as they are distracted with other tasks such as texting or some office related work and this is the reason the human error is a major cause for accidents and this increases the need to have a driver aid.

[3] Asplund, Mikael, Atif Manzoor, Mélanie Bouroche, Siobhan Clarke, and Vinny Cahill. "A formal approach to autonomous vehicle coordination." In International Symposium on Formal Methods, pp. 52-67. Springer, Berlin, Heidelberg, 2012.

This paper(Asplund et al., 2012) mainly deals with the coordinated safety-critical distribution. This showed how a Satisfiability Modulo Theories (SMT) can solve vehicle coordination complications. Also, a formalization of a distributed coordination protocol that validated their approach was made successfully.

[4] Margarita Martinez-Diaz, Francesc Soriguera, “Autonomous Vehicles: theoretical and practical challenges”, XIII Conference on Transport Engineering-IEEE CIT 2018, Halifax, Canada.

This paper(Martínez-Díaz and Soriguera, 2018) describes various autonomous driving frame work, keeping in mind the technicalities like the obstacle detection especially at high speeds and long distances. Also, the framework is validated with the help if simulation which will cover the hindrance for commercial and legal agreement of the autonomous driving.

[5] Hou, Xiangdan, Yongfeng Dong, Hu Zhang, and Junhua Gu. "Application of a self-adaptive Canny algorithm for detecting road surface distress image." In 2009 Second International Conference on Intelligent Networks and Intelligent Systems, pp. 354-357. IEEE, 2009.

The paper(Hou et al., 2009) works on improving the Canny algorithm by utilizing the C-means clustering algorithm. This canny algorithm can show better effects in the production of an image.

[6] R. Maini and H. Aggarwal, “Study and Comparison of Various Image Edge Detection Techniques”, International Journal of Image Processing (IJIP), vol. 3, Issue 1, (2009) February, pp. 1-12.

This paper(Maini and Aggarwal, 2009) focuses on an analysis of various Image Edge Detection techniques. Using MATLAB a software compares different image edge detection technique which displayed that performing Canny edge Detection is better than any other Algorithm. Their evaluation of the images proved that under noisy conditions this detection algorithm exhibit better performance in comparison with other operators. We have also observed it has also that Canny’s edge detection algorithm is computationally more expensive than other operators.

[7] Ghazali, Kamarul, Rui Xiao, and Jie Ma. "Road lane detection using H-maxima and improved hough transform." In 2012 Fourth International Conference on Computational Intelligence, Modelling and Simulation, pp. 205-208. IEEE, 2012.

This paper(Ghazali et al., 2012) shows a lane detection technique based on the physical representation of the lane. The principal Concern has been shown to the turning part of the road and because of low curvature, the detection of the lane becomes hard. The paper involves the Method of separating the image into a near field and far field view and filtering the noise from the image, which gives a better closer range result.

[8] Barash, Danny. "Fundamental relationship between bilateral filtering, adaptive smoothing, and the nonlinear diffusion equation." IEEE Transactions on Pattern Analysis and Machine Intelligence 24, no. 6 (2002): 844-847.

This paper(Barash, 2002) presents a relation between two different filtering technique namely bilateral filtering which deals with a huge number of non-linear images, filters, and adaptive smoothing. Separately, the adaptive smoothing is variable in showing data, but when it is related to anisotropic diffusion, it makes the result consistent.

[9 Paris, Sylvain, and Frédo Durand. "A fast approximation of the bilateral filter using a signal processing approach." In European conference on computer vision, pp. 568-580. Springer, Berlin, Heidelberg, 2006.

The paper(Paris and Durand, 2006) explains the concept of bilinear transform showing its effectiveness in dealing with the number of problems in the field of computer vision.Bilinear filter is analysed with different signal processing techniques to develop a novel filtering acceleration. This is achieved by expressing the filter to space with a higher dimension and where the intensity of the signal adds up with the original domain dimension which helps to express bilinear filter as a simple convolution in higher-order space with two nonlinearities allowing to achieve an efficient acceleration.

[10] Radford, C. J., and D. C. Houghton. "Vehicle detection in open-world scenes using a hough transform technique." In Third International Conference on Image Processing and its Applications, 1989., pp. 78-82. IET, 1989.

The paper(Radford and Houghton, 1989) studies, the technique involving a Hough transform algorithm for the determination of the wheels and wheel arches by searching for concentric arcs/circles of the wheel. It basically detects side views of vehicles with some changes in orientation of wheels leading to a generation of more detailed and robust object identification algorithms onto a batch of the complete image. An integrated set of algorithms generated by taking a grey-level image as input and producing a key region of the vehicle from an extracted wheelbase.

[11] M. Bertozzi and A. Broggi, "GOLD: A parallel real-time stereo vision system for generic obstacle and lane detection," IEEE Trans. Image Process., vol. 7, no. 1, pp. 62–81, Jan. 1998.

The paper(Bertozzi and Broggi, 1998) uses the concept of lane detection and object detection to present a Generic Obstacle and lane detection system (GOLD). The system is embedded with vision-based hardware and software architecture to heighten road safety. The system detects both generic objects and lane marking at the rate of 10Hz in a practical environment. Using the geometric transform which is provided by the hardware module, it removes the perspective effect from the left and right stereo images. The left part of the image determines the lane markings in the road and when it remapped with the other image, it displays the free space in the surrounding.

[12] Belaroussi, Rachid, and Jean-Philippe Tarel. "A real-time road sign detection using bilateral chinese transform." In International Symposium on Visual Computing, pp. 1161-1170. Springer, Berlin, Heidelberg, 2009.

This paper(Belaroussi and Tarel, 2009) presents the use of pairwise gradient-based symmetry transform which can detect signs in circles and polygon shapes. This transform symmetry is known as bilateral Chinese transform (BCT). BCT breaks down the object in Sets of parallel outline and models the generated field symmetry using a collection of radial symmetry data.

[13]Hou, Yuenan, Zheng Ma, Chunxiao Liu, and Chen Change Loy. "Learning lightweight lane detection cnns by self attention distillation." In Proceedings of the IEEE International Conference on Computer Vision, pp. 1013-1021. 2019.

This paper(Hou et al., 2019) presents a concept of Self-attention distillation(SAD) for lane detection. SAD works on a simple approach that allows the networks that deal with lane detection to make it learn of itself without the need for extra supervision or additional labels. Briefly, SAD can be Understood as an observation involving the training of a lane detection to a reasonable level and the maps which have been brought up at different layers gives the rough outline of scene and this learning is added to the half-trained model which strengthen the representation of lane. The major drawback this paper holds is that it's for boosting the performance of small lane detection network.

[14] Girshick, Ross, Jeff Donahue, Trevor Darrell, and Jitendra Malik. "Rich feature hierarchies for accurate object detection and semantic segmentation." In Proceedings of the IEEE conference on computer vision and pattern recognition, pp. 580-587. 2014.

This paper(Girshick et al., 2014) uses a detection algorithm known as R-CNNs, which improves the precision of data collected. The approach to get such precision involves applying high capacity CNNs to localize and segment the object, pre-training, and fine-tuning.

[15] Dosovitskiy, Alexey, German Ros, Felipe Codevilla, Antonio Lopez, and Vladlen Koltun. "CARLA: An open urban driving simulator." arXiv preprint arXiv:1711.03938 (2017).

This paper(Dosovitskiy et al., 2017)presents general information about the CARLA simulator. It explains the ease of use of CARLA has it provide content to test three approaches to autonomous driving: pipeline model, Deep network imitation training, and Deep network Reinforcement Training and because of these features, it gives Challenges to the road safety measures.

CHAPTER 3

SYSTEM MODEL

3.1 SYSTEM FLOW

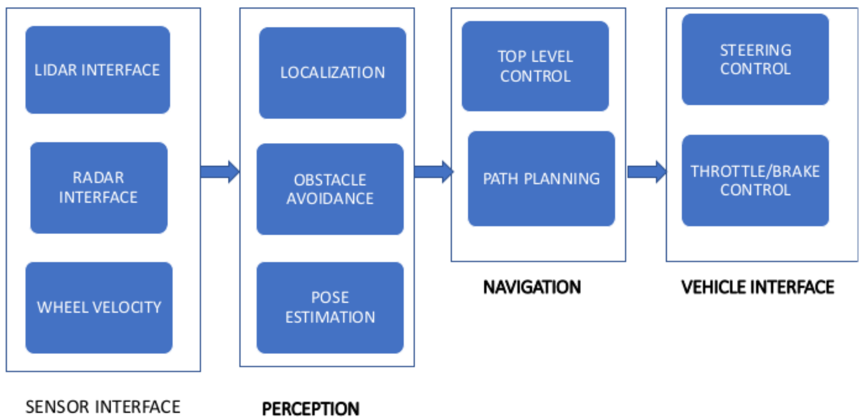

Figure 3.1: Proposed System flow

3.1.1 Sensor interface modules

This section indicates, all the communication between the sensors on the vehicle and the vehicle is done in this block. The section enables us to provide the various kinds of data from the sensors to all other blocks. The main sensors include camera, radar, GPS, IMU, wheel encoders and LIDARS.

Table 3.1: Performance Analysis of Sensors

Sensors	Bright Light Performance	Low Light Performance	Outdoor	Weather robustness	Vehicle classification	Vehicle adaption	Material Cost
Ultrasonic	Good	Good	Yes	Good	No	No	Low
Magnetic	Good	Good	Yes	Good	No	Yes	High
2-D Camera	Good	Weak	Yes	Weak	Yes	No	Low
Laser and Lidar	Good	Good	Yes	Good	Yes	No	Very High

The LIDAR SENSOR

LIDAR stands for light detection and ranging which uses laser lights to determine the distance between the surrounding objects, it is a useful sensor as it can measure up to 100m and give accuracy up to 2cm which is useful; The sensor will be the preferred option as the sensor is unaffected by climate, or any other conditions. The downside is the amount of processing power needed to run a LIDAR sensor efficiently and therefore the usage is limited.

RADAR

RADAR stands for radio detection and ranging, similar to LIDAR instead of using laser the RADAR uses radio waves (24 GHz) and monitors the reflection it is preferred over LIDAR (as of now) as it is a cheaper implementation compared to LIDAR and the system similar to LIDAR is unaffected to the change in surroundings, the limitation is that the RADAR gives us an output which is blurry and can cause errors in perceiving compared to LIDAR but with introducing mm-wave (77Ghz) technology in RADAR this limitation can be made more efficient.

CAMERA

This is mainly used as a replacement of the human eye and is useful in the detection of signals and the surroundings, but similar to the human eye the limitations are caused because of the surroundings, that implies if the weather condition is not ideal the sensor will not function properly, therefore, it need to be implemented with other sensors which can help the vehicle where the camera sensor cannot function properly.

SENSORS IN VEHICLE

The GPS sensor is used to find the real-time location of the vehicle and to better understand the path it needs to follow, the wheel velocity and steering sensor is used to understand the original position of the vehicle and the amount of changes needed to be given to the vehicle so it can work efficiently.

3.1.2 PERCEPTION MODULES

These modules perform processing on perception data from sensors such as LIDAR, camera, and radar and divides the data to find moving and static objects. They also help direct the self-driving vehicles relative to its digital map of the environment.

LOCALISATION

We understand the position of the vehicle in actual time that understands the surroundings. This is an important step as we need to understand that the surroundings so that our vehicle can predict or react if there are any changes needed to the vehicle position.

OBSTACLE AVOIDANCE

The Vehicle needs to ensure its safety, therefore it needs to avoid obstacles in its way and predict movements of various vehicles in its surroundings with the help of the sensors present.

POSE ESTIMATION

This is a method of joining the various images to have a better understanding of the object, this can help create a 3D depth map with the help of various sensors present which will help the vehicle avoid crashing or predict their movements, this can understand human poses.

3.1.3 NAVIGATION MODULES

This module determines the behaviour of the autonomous car. It has motion planners and finite state machines for different behaviours in the robot.Now that we understood what the sensors offered we need to process the information and react to it, similar to human beings, this stage is the processing stage. By understanding the surrounding we can train the vehicle to move in accordance to avoid collision this step needs analysis of an enormous data set which needs a lot of processing and is the difference between the various autonomous systems. For Path planning we need to make use of Several algorithm and techniques.For Lane detection, the techniques we have used are Hough Transform, Canny Edge Detection, Bilateral Filter.

Hough Transform

Analyzing an image and Processing an image, have the features which are retrieved by using Hough Transform. Considering an image space, the edge detection in the primary stage (pre-processing) is used to figure out the points in the desired curve. But images may or may not be perfect and the edge detector may have some imperfections too. So, because of that, few pixels may miss on the curve. To avoid this problem, the Hough Transform has been introduced.

Edge Detection

Depending upon the differences in the brightness of an image, Edges are estimated at those points. The main benefit of edge detection is that it does not acknowledge the data which is insignificant as the data that has to be processed gets reduced by the algorithm.

Figure 3.2: Edge Detection using Canny Algorithm

In this project, we have used Canny Edge detection as the algorithm for detecting edges which is a multiple-stage algorithm.

Bilateral Filter

The basic scheme of Bilateral filter is similar to the anti-aliasing technique, but leaving or preserving the edges alone without changing and smoothens the image if the two pixels are close to each other. This is a non-iterative scheme and used to make sure whether the vehicle follows the right path or not.

3.1.4 VEHICLE INTERFACE

After planning the path, the controller commands the steering, throttle, and brake control, are sent to the vehicle through electronic signals to control the vehicle.Vehicle interface is the reaction stage to the action, this involves sending data to the actuators i.e. steering control and throttle control to change direction or vary the speed of the vehicle under its surroundings this ensure that the vehicle remains in the desired path giving us the desired results.

3.2 PROBLEM STATEMENT

The Problem Statement is defined as

- To Reduce the number of accidents that occur due to human.
- To Ensure safety.

- To make driving longer distances more convenient.
- To Ensure that the vehicle health is maintained.
- Ensure only optimal amount of fuel is consumed.

3.3 NEED FOR STUDY

With the increase in the number of accidents that occur due to human negligence and the importance of creating an autonomous system using which the vehicle can travel without any human input from point a to point b. There is a need to have a better understanding of how to create a completely autonomous system at a feasible price as the current implementations are very expensive to create and use.

3.4 OBJECTIVES

The project aims to achieve following objectives:-

- To Create a Simulation of an Autonomous vehicle that performs edge-detection, path tracking and object tracking.
- To obtain high accuracy points with low validation loss which helps in efficient navigation.

3.5 REALISTIC CONSTRAINTS

- Despite improved and added interface of wearable heat sinks in the structure there can be a discrepancy
- Despite high cost it is more reliable and can be used in the future of generation of power with the needed optimization.
- Speed is medium and the Power output is expected to be high.

CHAPTER 4

RESULT

The use of udacity simulator we are able to train our model to give an accuracy of 90% on a left biased road (vehicles driving on the left side of the road) and we are able to understand the importance of training the vehicles ourselves instead of using only algorithms as there are a few cases where the algorithm with cause a very robotic movement of the vehicle and is certain to get off track or bang into some other vehicle.

Figure 4.1: Simulation on Udacity

The above images depict how the vehicle follows the track without going off track on two different kind of terrain.In Udacity the vehicle is manually trained to follow the path.While training, The vehicle captures the images of the path and generates a database which makes the vehicle to Autonomously follow the generated path.In addition, It also keep the track of speed,Steering angle,acceleration and brake. Using the Carla simulator, we were able to create a real time environment for validating our code. We are able to create a small world we real time objects, we were able to understand that our system worked perfectly in various weather conditions as well as various situations. We were able to detect traffic signals and stop signs in real time and were able to teach our vehicle how to react to the various situations that a vehicle would face on the road .To validate both the above software simulations, we were able to build a prototype and train the model using basic image processing and get the desired output.

Figure 4.2: Simualtion on CARLA

The image represents the vehicle detecting the objects in its surrounding to ensure it doesn't collide with anything in it's path or checks if any incoming vehicle is coming in it's path.

Figure 4.3: Detection of Green Signal

The above image represents our trained vehicle detecting the signal turn green with the help of object detection understanding that the vehicle can now move. It can detect the vehicles around it to see there is no issue or incoming vehicle before following its original path.

Figure 4.4: Detection of Red Signal

The trained vehicle with the help of object detection sees that the vehicle turns red indicating that the vehicle should stop and stays stationery until the signal turns green. When the Vehicle analyses the Signal colour and it display red its acceleration value automates to zero and vehicle stops at that point.

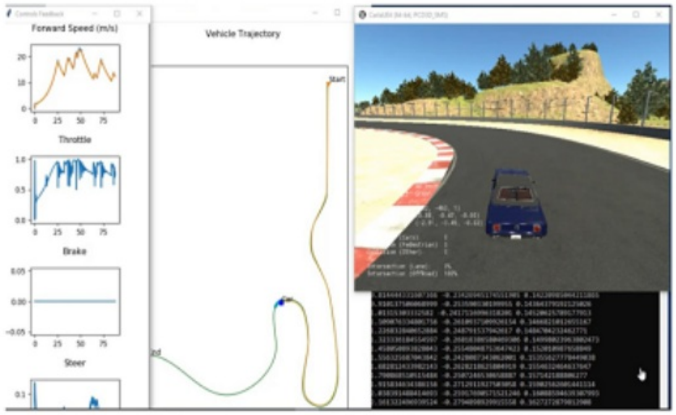

Figure 4.5: Data obtained from vehicle while training

This is a real-time representation of the Udacity simulator used, we can see that the location of the trained vehicle shown in terms of its coordinates at the bottom right telling, a 2D way-point created (in the vehicle trajectory file) by the vehicle to better understand the path to be followed under which our vehicle can vary the speed of the vehicle by changing the throttle input in a way as we can see this is done without breaking, in this case, reducing the losses caused because of braking saving fuel. The steering angle is calculated by measuring the change in the road's angle. This method helps the vehicle in following its path without going off track, giving high accuracy. This result verifies our code, giving us the desired accuracy. The vehicle can travel from a point and point, a set on the waypoint without going off the track and by following the lane whenever needed.

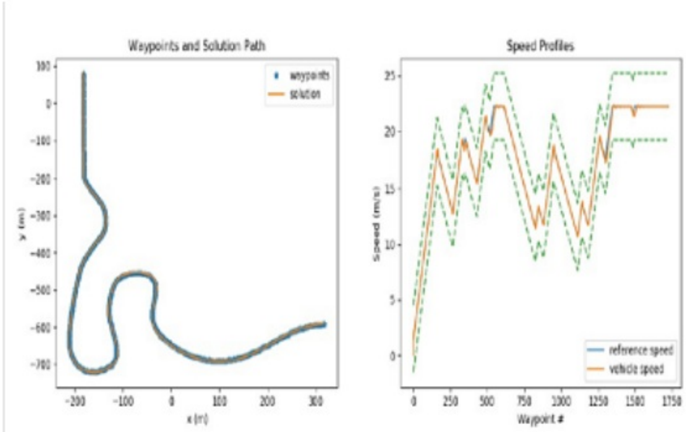

Figure 4.6: Generated waypaths and speed profile

For the graph depicting way point and solution path, we created a 2D path for the autonomous vehicle to follow by providing necessary way point to find out the precision and accuracy of the vehicle.The reference speeds of the vehicle are given by us during training and the vehicle speed is a graphical representation on how it lies between the reference speeds all the time.

CHAPTER 5

CONCLUSION

This paper deals with a different approach to level 3 autonomous driving by using relatively inexpensive hardware compared to the real time vehicles present on the roads. The use of CARLA and udacity simulator helped us understand the constraints that autonomous vehicles faced and how using naturalistic driving solutions we are able to obtain a more interactive driving experience. Using the above results we can understand that by increasing the possible data sets and with continuous training of the above code we can take this project to higher levels of autonomy. The only constraint in the paper is acceptance of autonomous vehicles in a sea full of drivers. But this is a step towards a more accepting approach as the results have proven to give a really high level of accuracy and is only bound to improve with time.

CHAPTER 6

FUTURE ASPECTS

There are Several aspects on which work can be done in future and this project can serve as a reference.

6.1 EVOLUTION OF URBAN CENTERS

There is major problem with cities now days is the traffic, and each place is getting over-populated, there is a need to reduce the number of idle vehicles on the road or parked on the street there is a possibility that multiple people can use one vehicle, therefore, saving a ton of parking space, this in return is a way of optimizing the present resources that we have. The above future will require level 5 autonomy, which can only be achieved by perfecting the present system.

6.2 REDUCED EMISSIONS

We have noticed that the entire world is moving towards electrical mobility it is not possible to phase out petrol-powered vehicles, with the help of optimized acceleration and braking we can optimize the fuel usage of vehicles.

6.3 MORE INDEPENDENCE

There are a huge number of people that are physically challenged, they feel limited to a few tasks which limit their growth or their contribution In society by providing them a fully autonomous system that can help transport them and hence letting them grow as people and do good for the world.

6.4 MOBILE BUSINESSES

Companies like UBER have already started their research on autonomous driving as they know the importance of the removal of human error while driving and know that people would feel safer if they didn't have to depend on anyone to get their work done. This will still take time as people don't trust software. But it is a possibility and will happen as it's the next step.

6.5 LEVEL5 AUTONOMOUS VEHICLE

Majority of the accidents that occur because of human error, there is a need for providing such a system that can reduce or completely stop these accidents. Training a vehicle to function autonomously and manage between humans without being able to differentiate which is a human driver and which is an autonomous vehicle is the goal set to be achieved in the coming years and perfecting level 3 is a major step as after that only the data set matters.

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Naturalistic driving simulation

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