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Self-Driving Cars using Genetic Algorithm

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Abstract: This paper deals with a 2D unity simulation of an autonomous car learning to drive in a simplified environment containing only lane and static obstacles. Learning is performed using the neural network and evolutionary algorithm. The cars navigate by evolving themselves from the previous generation. The neural network used in this paper is standard, fully connected, feed forward neural network. The cars are steered by a feed forward Neural Network. The weights of the network are trained using a modified genetic algorithm.
Keywords: Autonomous Car, Self Driving cars, Deep Learning Cars, Genetic Cars, Self driving cars using EANN.

I. INTRODUCTION

Autonomous vehicle was an imaginary idea which came to reality with advent of deep learning based machine learning in AI. AV’s main motive is to bring a safety to driving. Human driving is an accident prone. We are drunk, tired and irrational decision maker. 2019’s annual report of the International Traffic Safety Data and Analysis Group (IRTAD) over 1.3 million people lost their lives annually and 10 million people are seriously injured [10]. More than 50% of those injured are pedestrians. AV can bring possibility to replace accident prone human driving by providing safety and comfort.

Fayjie et al has applied an approach for obstacle avoidance and navigation in urban environment using Deep Reinforcement learning applied Deep Q network. Camera sensors and laser sensors are used to collect the input data. This approach uses Hokugo Lidar and a camera. For running a deep learning algorithm it uses an embedded GPU.

GA is good at searching large-scale, complex, non-differentiable and multimodal spaces; it doesn’t need the gradient information of the error function. On the other hand, it doesn’t need to consider whether the error function is differentiable, so some punishments may be added into the error function, so as to improve the network commonality, reduce the complexity of the network.

This paper is organized as follows. Section II presents summary of challenges for autonomous vehicles and problems that have been overcome by different methodology. Applying evolutionary algorithm on N cars to navigate themselves through different courses and avoid obstacles is given in Section III. Section IV presents conclusion.

II. RELATED WORK

PROMETHEUS was first project for fully autonomous vehicle in which Unibw Munich and Daimler Benz presented AV in three lanes with speed 130 km/h. important perception task field of AV are Vehicle state estimation, Static obstacle, Traffic participants, road shape estimation and map aided localization [3].Hafeez et al. [1] proposed a comprehensive review over areas of Autonomous Vehicle (AV), discuss sensor fusion technology & challenges faced for a fully AV. To obtain human like thinking capability requires the huge amount of surrounding information which is fully depended on the onboard sensors installed in AV. Not only sensor fusion is important but also an optimized decision according to the intention of pedestrian is required for a fully Autonomous Automation. The basic framework of AV consists of: - Perception, localization & mapping, path planning, decision making & vehicle control. Pedestrian Intention Prediction (PIP) is critical aspect of AV. Vehicle can be set to automatically navigate to the destination using other vehicle in front of it having same destination. [4] Memon et al represented a miniature model of semi-AV. Author used Google maps API to avoid obstacles and follow the car in front which has same destination as the test car. As it is a semi autonomous vehicle humans plays a vital role. [5] James et al. proposed a concept of mathematic model for vehicle dynamic. The data of large scale experiment from two vehicle Lancia Delta car and Jeep Renegade sport utility vehicle was analyzed. Both the data driven model outperformed the physical model, neural network model. State-space model performed almost well for Lancia Delta but fell short for Jeep Renegade whose dynamics where more strongly non-linear. [2] Humans are still an essential part of driving task. AI system performance must be watch over anywhere from 0% to 100%. Driver assistance aspects, driver experience and vehicle performance are increasingly being automated with learning based approaches in order to achieve AV. [6] paper overviewed a challenges, opportunities and future implication for the transportation policies. AV technology provides finely tuned acceleration braking maneuvers at all times while constantly and tirelessly monitoring the surrounding traffic environment. Real time data can be processed and analyzed in order to calculate and direct AV toward the best possible route.

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Perception of the environment remains the biggest challenge to reliable and safe driving. [7] Authors presented control strategies, robust control strategies and parameter observation based control strategies on path tracking for autonomous vehicle. Autonomous Vehicle technology's main aim was to improve driving comfort, safety, economy as well as reduce road accident rate. Path tracking is a basic part of autonomous vehicle aims to follow the route accurately, ensure vehicle stability and satisfies the robust performance of the control system. [9] Author has applied an approach for obstacle avoidance and navigation in urban environment using Deep Reinforcement learning applied Deep Q network. Camera sensors and laser sensors are used to collect the input data. This approach uses Hokugo Lidar and a camera. For running a deep learning algorithm it uses an embedded GPU.

III. METHODOLOGY

The first generation starts with 20 cars each of them having its own neural network, makes its intelligence. They have five front facing sensors covering approximately 90 degrees. The maximum range of sensor is 10 unity units. The neural network comprise of 4 layers, the first layer is an input layer with 5 neurons, two hidden layers having 4 and 3 neurons and an output layer with 2 neurons.

The steps of using GA to evolve the ANN architecture are as follows:

1) Step 1 Randomly generate N architecture, and code each architecture.
2) Step 2 Train the architecture in the individual set using many different initial weights.
3) Step 3 Determine the fitness of each individual according to the trained result and other strategies.
4) Step 4 Select several individuals whose fitness is the largest, directly passing on to the next generation.
5) Step 5 Do crossover and mutation to the current population, to generate the next generation.
6) Step 6 Repeat Step 2 to Step 5, until some individuals in the current population meets the demand

The weights of neural network are trained using genetic algorithm. At first there are 20 randomly initialized cars spawned. The best cars are selected and recombined and create new offspring cars. These offspring cars create new population of 20 cars which are slightly mutated in order to inject more diversity into population. The newly created cars then try to navigate the course again and the process of evaluation, selection and recombination and mutation starts again one complete cycle from evaluation of one population to the evaluation of the next is called a generation.

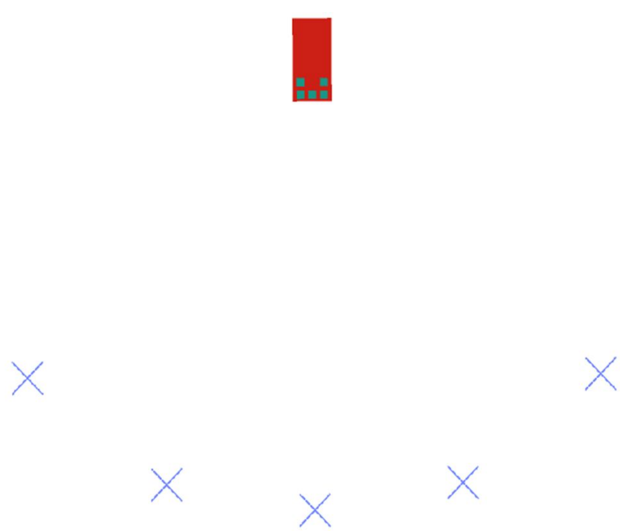

Figure a. self driving car with front facing sensor

The first five points you are seeing in fig a are just the current reading of the five distance sensors of the car. These sensors measure the distance to the nearest wall. The blue crosses are simply there to visualize where the sensors are currently pointing. They all have their own weights. However they share their learning in the sense that best individual of one generation are used to create individual of next generation. In the order to create new individual two other individual are crossed and the offspring is then mutated. This mutation makes them better than previous generation.

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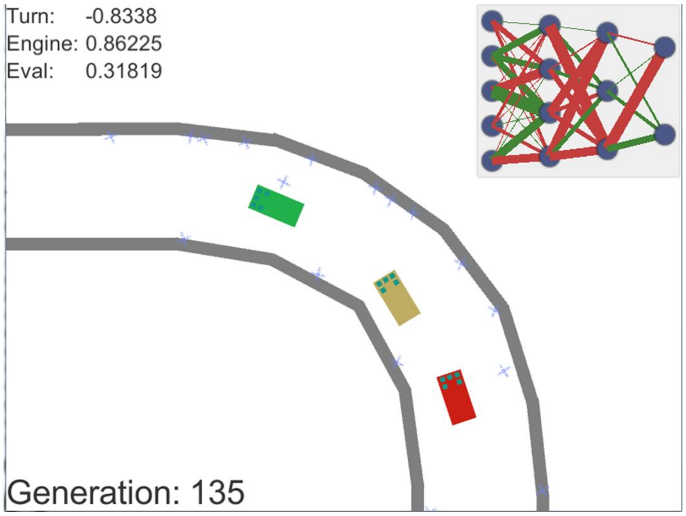

Figure b

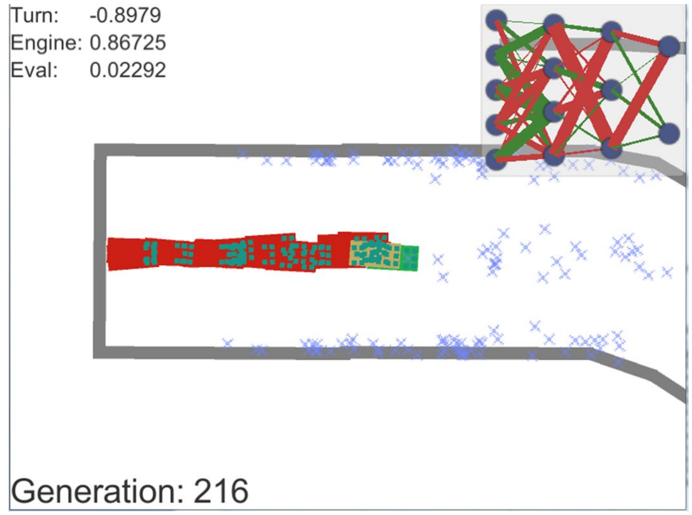

Figure c

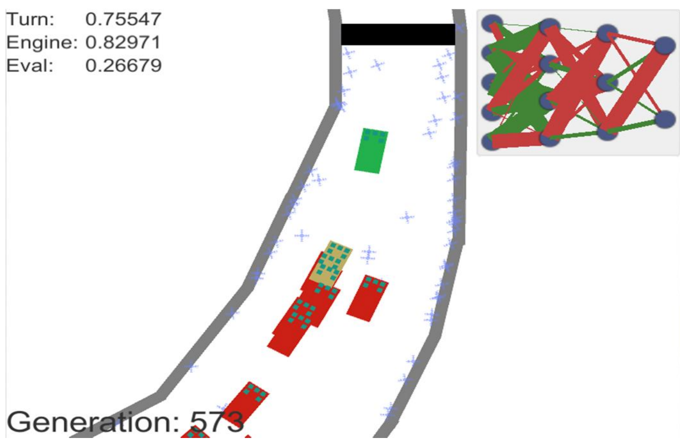

Figure e

IV. CONCLUSION

In this paper, an approach of deep learning in autonomous car learning to navigate in a simplified environment and static obstacles is proposed. This approach used a Neural Network and evolutionary algorithm to train the car in the 2D unity simulated environment. The verification results are expected to demonstrate that learning autonomous driving in a simulated environment is a step towards driving on real streets.

V. ACKNOWLEDGEMENT

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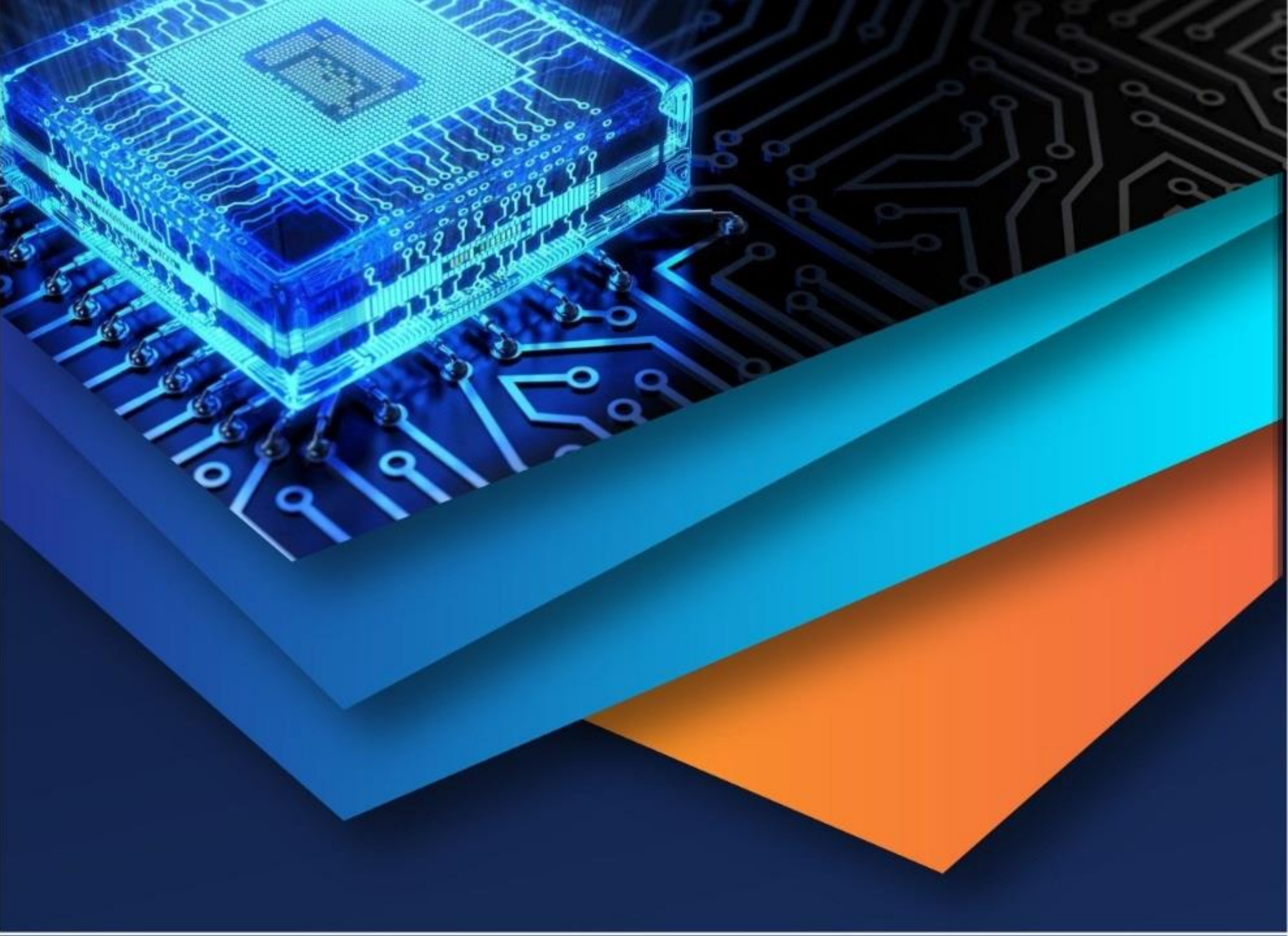

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