Autonomous Vehicles

Jeel Gondaliya
Computer Science, Dalhousie University
jeel.gondaliya@dal.ca

The autonomous vehicle has been a buzz word for the last five or ten years. This innovation will provide several benefits related to safety, the environment, and enhanced experience. Autonomous vehicles will reduce accidents, which were happened due to human error. So, there will be fewer deaths and injuries on the road. This innovation will reduce traffic and CO2 emissions, which eventually helps to reduce pollution. The main advantage of autonomous vehicles is access to transportation by elder people and people with disabilities. The main two factors of this innovation are machine learning and robotics. Autonomous vehicles reduce the cost as it consumes a lesser amount of oil compared to the current vehicles. This will enhance the user experience and it is environment-friendly, which solves the biggest issue in the world, environmental pollution. This innovation will make a huge change to the transportation system in a good way.

I. Introduction

Vehicles have shaped the world in many ways, it eases transportation worldwide in many forms. The evolution of vehicles is a continuous process and it brought a huge change to the world. In the beginning, the vehicles were operated by steam engines, then petrol and diesel, and now electricity. However, it also created a few challenges like pollution, traffic, land usage, and accidents. Autonomous vehicles are the greatest evolution in transportation, it is the solution to the few problems like traffic, land usage, and accidents. It is designed to reduce pollution and accidents which happened due to the human driver's fault. It also uses the minimum land and reduces traffic. The process of developing autonomous vehicles includes the solution of the existing problems and management of the risk from this new technology. Deep Learning and Reinforcement learning play an important role in the development of autonomous vehicles. Deep Learning is useful for image processing and vehicles can learn from the existing data using neural networks. Reinforcement helps vehicles to learn on their own after giving some amount of training.

Vehicles have five different types of automation levels, No automation, Driver Assistance, Partial assistance, Conditional Automation, High automation. Level 0, No automation is the vehicles, currently, we are using. And Level 5, High automation has no driver at all, zero support from a human. Most of the big companies are working on level 5 automation. The autonomous vehicle is the revolution, on which many big companies like Tesla, Google, Nvidia, Uber, and more, these companies have invested more than a billion dollars for developing autonomous vehicles. The revolution of autonomous vehicles is not so far, some of the top-notch company announced to launch autonomous vehicles by 2021.

II. System Architecture

Two main components of autonomous vehicles are convolution neural networks and reinforcement learning. Convolution neural network (CNN) is used for image processing and object detection, which is a very important factor in autonomous driving. The vehicle needs to detect the objects in their ways and need to make a decision based on the objects. The learning part can be done as reinforcement learning, especially when we do not have enough amount of data. CNN and Reinforcement learnings are powerful algorithms in machine learning and the main reason for the revolution of vehicles.

The advantage of CNN is the automatic feature extraction. Previously all the classification models were followed by feature extraction methods like information gain, entropy, and Gini index, however, now the CNN model can learn about necessary feature extraction in training using filters like padding, max pooling, average pooling, convolution matrix, and edge detection. CNN is the most important part of the autonomous vehicles for pattern recognition. Reinforcement learning is used when all the possible situation is not possible to store in the dataset, Vehicles can learn on their own after training with few possible situations.

Data Collection

The development of autonomous vehicles has three phases, data collection, pattern recognition using convolution neural network, and learning phase using reinforcement learning or fuzzy logic. The first phase of data collection includes everything from the way data can be collected to the quality of the data and what kind of data should be feed to convolution neural networks. Vehicles have a camera attached to the front side to collect all the data in the form of videos. All the cameras are placed in a way that reduces the data redundancy, which means that the video or image captured by one camera should not be repeated in the other cameras. The reason to avoid data redundancy is that the number of features should be as minimum as possible because it increases the processing time. To collect the training data the first driver is operating the car and based on that the model will get an idea about the situation and angle of the steering wheel. The videos or images are collected from all the cameras and passed to the convolution neural network, that's when the second phase will be started. The data can be the edges of the road, the temperature outside and the angle, and the speed of the steering wheel.

Train the model using CNN

In the second phase, the data in the form of images are passed to the convolution neural network and the steering wheel is integrated with the convolution neural network. If the cameras record the data in the form of video, then the videos will be broken down into images based on interval time like one millisecond or one microsecond. In the next step, feature extraction is performed in a convolution neural network using pooling, padding, vertical and horizontal edge to detect objects and patterns. The feature map after feature extraction is passed to the neural network where backpropagation happens which trains the model based on different situations. Spatio-temporal CNN can be used when data is in the form of videos. Convolution neural networks train a model to learn patterns and to make a decision based on the recognized patterns.

Reinforcement Learning

The third phase is not used widely but I feel that this phase can change the game of autonomous vehicles. I am considering Q-learning for this phase for reinforcement learning. While driving a car there are many numbers of different incidents that can happen and collecting all the data is impossible. This is the reason for autonomous vehicles not being launched in the market. However, if we train a vehicle based on some of the given situations and it can learn to deal with unseen possible scenarios then all the problems are solved. This is reinforcement learning, where the model is trained based on a few scenarios and it can deal with unseen patterns on its own. Q-learning is a very powerful technique when there is no enough data or it is impossible to gather the data which includes all the possible scenarios or situations. Hence, that is the exact cause of autonomous vehicles, where it is quite tough to collect data with all the possible scenarios and that is why companies are working on reinforcement learning algorithms for the innovation of autonomous vehicles.

III. IMPLEMENTATION

From a design challenge perspective, this innovation can be implemented easily considering all the phases of the design challenge. In the empathize phase, most of the companies targeted a particular city or small area of a city where they can launch the final product. From that city, the product can increase the market demand and can be used worldwide. I will take interviews of people who are living in that area about what they think of autonomous vehicles. Because half the people in the world think that autonomous vehicles can be dangerous. Hence, I should target the cities where the majority of the votes are positive for innovation. In the definition phase, User needs, the negative and positive impacts should be gathered. First of all, how users' requirements are related to innovation, should be figured out. Also, every innovation has positive as well as negative impacts. So, the solution to all the negative impacts should be discovered.

In the ideation phase, I came up with as many ideas as possible and note down everything. For example, Autonomous vehicles can be developed using many different machine learning algorithms like reinforcement learning, convolution neural networks, Long-short term memory RNN, and more. And after gathering all the possible innovative ideas and solutions, the feasible ones should be selected. The next step is very important and carries a lot of weight because this is the phase where I might add many things and we remove some ideas if it is not possible to implement or not feasible. Firstly, I came up with all the possible ways to collects data and all the possible forms in which the data should be collected. Data collection is a very important step in machine learning modeling because all the possible outcomes depend on the collected data. The next in the ideation phase is to determine the machine learning algorithms which can identify the objects and make a decision by analyzing the image or video data. There are many algorithms available in machine learning to process image data but according to the recent finding, the convolution neural network works best with the image data as it can be trained to perform feature extraction automatically. I also read some of the popular research paper and conference journal which are using CNN. Hence, I decided to move forward with CNN.

IV. RESULTS

The most important to worry about autonomous vehicles is to deal with negative impacts. If one in a million cases goes wrong, it can take a person's life. Hence, it shows that the model should be a hundred percent accurate to launch autonomous vehicles in the market. As a result, some companies have already developed autonomous vehicles, but they have not yet launched vehicles in the market. Because there are some improvements need to be done. That is what all the companies right now working on, they are trying to solve all the possible flaws the vehicle might have. The model should be trained based on all the possible situation or incidents can occur while driving a car. It a lot of data! Convolution neural network has many layers and it will take a lot of time for processing if the amount of data is very big, that is a big issue now to worry about. Because while driving a car, the decision should be taken in seconds otherwise all these models and automation have no benefits. So, the major issue now is how to process a huge amount of data in a very short period and make a decision as soon as possible.

In the testing phase, all the companies now, are testing the autonomous vehicles for different situations. They are using different algorithms to train a model. They are also figuring out different ways to collect data from the camera, from different angles, and high-quality data.

V. CONCLUSION

Soon there will be autonomous vehicles on the roads in big cities. Over the last ten years, autonomous vehicles have developed a lot from Level 0 – no automation to Level 4 – conditional autonomous. Also, some of the companies like

uber and tesla, are already working in Leve 5 automation, so it is not so far when there will driverless cars running on the road, it is all the time. I believe in this innovation because it has made remarkable progress in a very short period. As of now, companies are working on how to deal with the negative impacts of autonomous vehicles and they will have a solution very soon. The progress in machine learning and especially in computer vision has helped a lot in the success of autonomous vehicles. Autonomous vehicles will bring a huge change to the world, hopefully in a good way, The autonomous vehicles will reduce traffic, pollution, and accidents. If it is used in the right way, It will make the world a better and safer place!

REFERENCES

[1] (2020). Retrieved 4 March 2020, from https://www.researchgate.net/publication/324095773_Self-driving_cars_-_The_human_side

[2] (2020). Retrieved 4 March 2020, from https://www.researchgate.net/publication/311843099_Self-driving_and_driver_relaxing_vehicle

[3] (2020). Retrieved 4 March 2020, from https://www.researchgate.net/publication/328403854_Fuzzy_Logic_and_Deep_Steering_Control_based_Recommendation_System_for_Self-Driving_Car

[4] (2020). Retrieved 4 March 2020, from https://images.nvidia.com/content/tegra/automotive/images/2016/solutions/pdf/end-to-end-dl-using-px.pdfhttp://www.ijsrp.org/ijsrp-paper-format.php

[5] (2020). Retrieved 4 March 2020, from http://www.ijsrp.org/ijsrp-paper-format.php

[6] Graduate paper topic