Blockchain Integrated Machine Learning for Training Autonomous Cars

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Abstract: Autonomous cars have always been fascinating towards the coming generation of we techies and since then training them has also been an important concern. That's when we can consider Machine Learning integrated with Blockchain to provide high security to build this model. Machine Learning and Blockchain are two very innovative domains of computing. There has been a constant improvement in neural networks in past years. Since Artificial Intelligence-based learning algorithms are taken into account and a drive towards the training of autonomous cars is seen. Here, we are going to train a single car with great precision and accuracy, and then this alone trained car will share the data with all the other cars in its network. Hence, all of them will be sharing a particular network and the data will be exchanged. Now, when it comes to the learning of cars, we will be creating a blockchain network that will connect every car for that particular company. In this way, while in a dynamic condition also, the cars will stay connected with each and every one and the data will be exchanged. So, the training will be done using Deep Neural Networks and since the data transfer and weights update requires high security, we will be using Blockchain. For example, if any car gets hit by an accident or due to any possible fatal breakdown or due to any changes in the route or signals (government laws), this data will be transmitted to each other car in this network. Hence every car will get its weight updated to avoid or tackle the situation. This in the end will decrease the computational time and increase the measure of safety and well-being.

Keywords- Blockchain, Machine learning, Deep Neural Network, Solidity, Ethereum, ledger, Deep learning, Image processing.

1. Introduction

A self-driving car, also known as an autonomous vehicle (AV or auto), driverless car, or robo-car, is a vehicle that is capable of sensing its environment and moving safely with little or no human input which is possible by Artificial Intelligence [4]. Training Machine Learning (ML) models require numerous processes, out of which Deep Neural Networks (DNN) is the one. We can see the growth in leading Autonomous/ Self-driving cars manufacturers like Tesla, Waymo, GM, Ford, and many more with their increased precision and accuracy. They have been constantly training their models to compete in the real world [1]. Our past technology states to train all the cars in the manufacturing process one by one which could take a huge computational time. Although the recent Tesla models have the method of collecting data/ inputs while traveling, it needs to be trained and the weights need to be updated from the service center [3][8].

Road accidents are constantly increasing for decades and this could be a major issue [32]. Every year more than 1.2 million people die and more than 50 million people get injured due to these road accidents and hence it is a major source of fatality and disability. In the United States on average, a human driver makes an accident after every 88 million miles. So, the model to make self-driving cars efficient and highly accurate to compete with the human brain won't be an easy task [3]. Several real-life examples can be seen when it comes to fatal accidents, due to human misunderstandings. But not that we can say autonomous cars are performing well. The recent case of Tesla's autopilot can be considered as a machine learning/ algorithm error where it was not able to detect a white truck under a bright sky. This case is an example of how much humans have to evolve to compete with their very own human brain [1].

Problem Statement

The main idea is to decrease the computational time required for training autonomous/self-driving/driverless cars using machine learning integrated with blockchain for passing the weights of the updated model over the entire network. According to the current scenario, every car is trained individually and this requires a huge amount of time for every car. Training an autonomous car is itself such a tedious task, which involves so many resources and human efforts. So, now we can imagine how will it be for these manufacturers to train every autonomous car individually. And thereby, we want them to manufacture and train only one car with great precision and accuracy. This car will pass on the details/parameters to all the other manufactured cars of that particular company. Over that, these autonomous cars will be having a network in which each car will be linked with one another (like a mesh network) and they will be sharing all the real-time information.

2. Literature Survey

The literature and a lot of research journals didn't give us the whole perspective about this scenario and it was a challenging task for us to work on this problem statement. Although we got a brief idea of how things are going to be and how we are going to proceed. The below research papers helped us in a significant manner.

The authors in [1] helped us in understanding the neural networks and their requirements. The paper gave us a brief on DNN for autonomous cars. The authors in [2] provide an idea about the abstract for how blockchain can be used in supply chain management. The supply chain management was then studied for implementation of Blockchain. Then, the authors in [7] gave us an idea about the real-time scenario and the restrictions whilst implementing the problem statement. Further, the authors in [8] gave us the basic idea of how things can be taken off and how the procedure needs to be followed.

The authors in [9] helped us with the smart contract technology and the data transmission when weights are getting updated. The authors in [10] in the paper gave us the idea of this problem statement. We added some of our elements and ideas to it and the research consists of several such metrics. The authors in [11] helped us understand the delay in these connected vehicles. Since the weights will be updated now and then we need to consider the time delay when the weights are updated.

After understanding all of these, we were able to classify the problem statement into 3 parts. The first one will be the classification of the machine learning model and its implementation for the real-world scenario. But for computational time, we took a part of a deep learning method or a miniature version of it to simulate in our computers. The second part will be building this Blockchain technology. This can be done either on solidity IDE or ethereum.

3. Existing Solutions

When it comes to manufacturing a self-driving car, it's not all about data inclusion and accuracy. We have to consider several factors when a supply and demand chain is created. We need to look upon the training model, its precision, and overall, we need to show our data to the end customer for the reliability of the product, as in the end, it's the life that matters and not the technology. So, with great technology comes great responsibility and we need to make sure that the existing solutions are efficient to surpass the demand. Various manufacturers are using different classification models, image processing techniques and have integrated with this chain and also have attained a lot of significant attraction to tech buddies. Deep learning models, integrated with digital image processing and signals and systems are now implemented in these cars, and the training dataset is modified again and again to keep the weights updated.

The launched cars learn by themselves and they eventually grow in the given environment. Now, this environment need not be friendly for another car which has not faced it till date. As when time passes by, there are going to be changed in the environment and we need to consider this case strictly and consider this as an important concern when it comes to safety. It's not necessary to have the same signboards over time since the car was manufactured and the government policies keep on changing. To date, every car is trained separately and they are completely unaware of their surroundings. We train the car once when we purchase and then only after service the car gets updated. Also, in which we cannot make sure that every user gets their car serviced in due time, after which may be due to any fatal case, the company will be responsible. The training time is directly proportional to the number of cars, which is not physically possible as and when the company receives high demand.

The existing solutions were studied and the drawbacks were considered, which can be implemented by any company, and we have seen a significant interest in the planned technology.

Why Blockchain Technology?

As we all know, blockchain is one of the most trusted technology when it comes to privacy and security. Their hashes and proof-of-work along with voting policy make them highly stable and when it comes to establishing autonomous vehicles, it is very important. The hashes in the blocks will be created, and the proof-of-work will be given significant importance since we need to change data as soon as it is received. The trained weights will get updated/ added to the dataset or trained model and thus we have integrated Machine

Learning with blockchain for self-driving cars. Here, we need to make sure that temporary events such as accidents, or potholes should be stored in temporary memory so that it can be cleared with ease. Since modification to a hash of a block needs time, we need to keep it minimal but at the same time, we need to consider the security aspect as well. We will be further enhancing the model since when there's a huge sale in the market, there might be too much delay in this network, as there are too many links and excess data transmission.

4. Proposed System

So, above we got to know that the computational time is going to be very high when it comes to production on a mass scale. And also, we need to consider the man-force required to achieve that task. Here using our idea, a company can improve a driver's safety as well as communicate with the car. Here, we are going to train a single car, and just like a teacher teaches several students, this car will teach/ share data with every other car. In this way, there's no need to train each car separately. Errors, while computing will be minimized and most importantly manufacturing time, will be reduced. Further, we are now going to use blockchain technology to integrate the data of every car to get the weights updated after each run. This network will consist of a unique ID of every car that will be linked to an organization's public ledger in which each car will be interacting with every other car, simultaneously the weights will get updated. The illustration below will help us understand the logic in a better way.

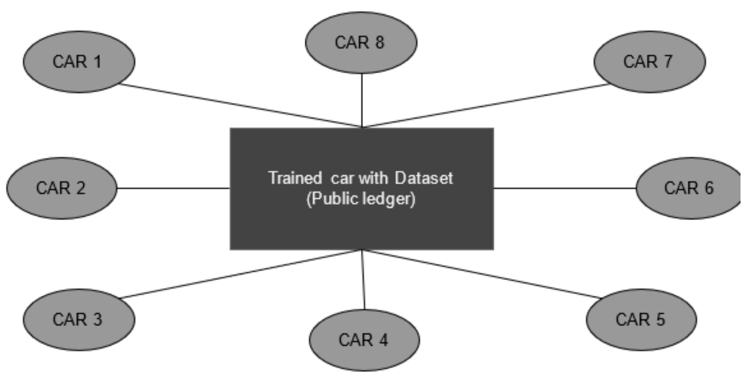

Figure 1:The sharing of data between parent car and child cars

The network shown in *fig. 1* demonstrates that once the data/ trained dataset is stored in a ledger, it will be accessible to every car. Every car now will be learning from the superficial car, and thus for any minute changes also we can take the risk, as we don't have to operate for every car. In this way, the computational time will be reduced in a significant way. For this, we can use Hybrid blockchain technology to keep the dataset as well as learning models private. Furthermore, the next blockchain will avail the facility to connect every car. For that, we need a machine learning/ Deep Neural Network (DNN), and the weights updated for the next instance need to be updated. The execution will be shown in the next section.

The illustration in *fig. 2* is the learning of a car. As soon as it is interrupted, a signal will be sent (this signal can be modified as per the company's need).

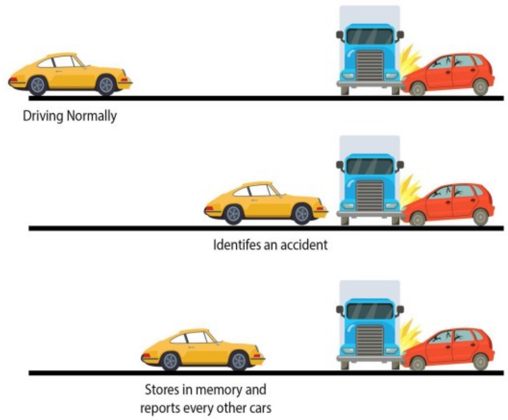

Figure 2: Data needs to be manipulated and weights need to be updated

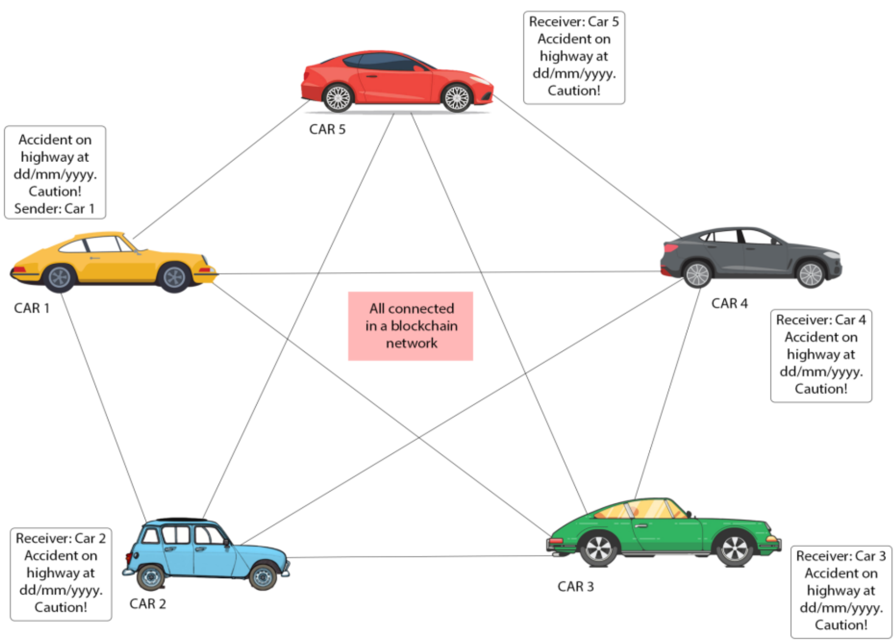

Figure 3: The network of learning and data transmission

The illustration in *fig. 3* the interconnected network on a small scale and we can see that the data will be exchanged amongst cars in real-time. In this case, car 1 gave the updated weights to all the other cars, and the same has been received by them. Car 1 transmits the interrupt/ message signal to all the cars 2, 3, 4, and 5 in a blockchain network. We can see that these cars are interconnected and so if there's a message from another car it can be received.

5. Implementation

After getting a brief about the idea, we need to implement the model's using python and solidity IDE. We need to focus upon the working of the model since as of now, it's just the working that's important and not the accuracy. Further companies will be requested to add their own parameters for this working environment.

Machine Learning Model

The Deep Neural Network needs to be created for the "teacher" car. Here in our model, we took five sensors so as to detect the edges of the track. Since it is a miniature model, we have not considered image processing in this and implemented based on 2-D architecture. Companies can integrate a high level of Artificial Intelligence when it comes to implementation in real life. The track was created and the DNN model was implemented for this car. For us to keep track, we tried many iterations with the same cars of different configurations and found the best possible fit. This highly trained car can be used to share the memory with every other car. Advantages, as mentioned, are less computational time, less amount of skilled labor, and help in the production at high demand levels too. If there's a major change that needs to be made, then to this network will help, and not every driver needs to come to the workshop and get their model updated. This will attract a lot of users and the increased convenience of users can also be seen.

The sensor weights will get concluded to a number less and similarly again the weight will get concluded to the end where it's just the acceleration, brake, steer left, and steer right as seen in any traditional DNN. The images/ figures 4 a, 4b, and 4c below show the implementation of the model:

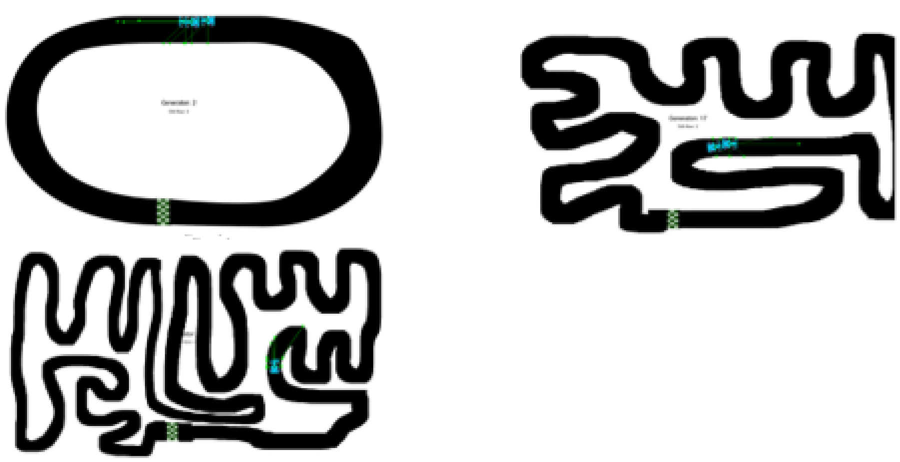

Figure 4 (a), (b), and (c): Implementation of the model (Left to Right)

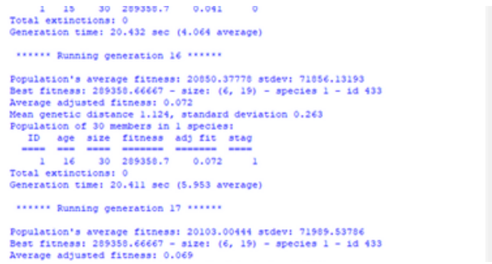

Figure 5: The tracks and updating weights after every generation

Considered 25 cars with different specifications so as to find the best fit. We can see that the toughness of the track is increased with an increase in iteration. In *fig. 4* the circular track is created and the cars were able to perform well in 4-5 iterations themselves. We found out that the cars took around 100-300 iterations including different specifications so that they can cross all over the track without any error. Similarly, it took around 1000 -2000 iterations so as to clear till the finish line and win the next round. After every collision that the car has avoided, it is rewarded with a bonus to keep track of, and if it crosses outside the track a penalty is charged. Further, this can be continued by designing more tracks and adding many more modifications such as traffic lights and potholes/ zebra crossing. Digital Image Processing is a must to be added when it comes to real-time implementation.

Blockchain network: As we know that, the parent car will be teachi0ng all the child cars, we need to implement that in a blockchain network where the admin will be the company's management/ technical department and they will act as a public ledger including the parent car. For data transmission during dynamic conditions, we have a demo blockchain implemented below. The blockchain shown below can be incremented to any scale till the company has a sufficient amount of delay time.

The *fig. 5* above show us a demo implementation of the blockchain network. This blockchain network can be implemented on Solidity IDE, Python, Java, or Ethereum depending upon the convenience of the customer base. Any third-party malware cannot change the hash of any block which will lead to an error. This would be given permission for the management and hence the weights will be updated accordingly.

In last, serval privacy preserving techniques for Vehicle Adhoc Network (including future vehicles) has been included in [21-30] in detail. The researchers are recommended to refer these articles for enhancing their knowledge towards preserving of privacy of users in this smart era with emerging technologies/ modern tools.

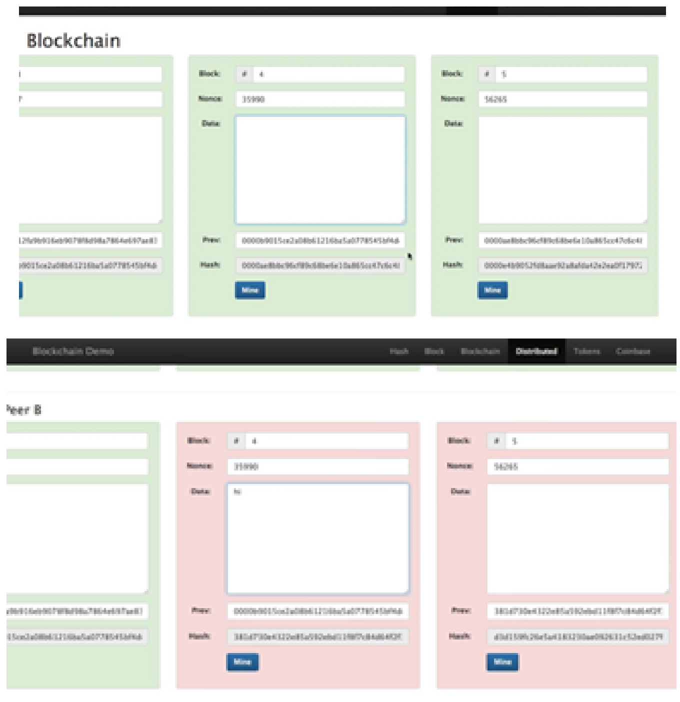

Figure 5: Blockchain Demo

6. Future Work/ Open Challenges for Future

We need to extend the training algorithms so as to minimize the update of weights again and again and so we have implemented the parent and child car idea so as to increase consumer/user convenience. The work done needs more clarification for updating the weights. The expansion of this blockchain network might lead us to delay data transmission. We need an interface that will catch the updated weights (python code) from a car and that needs to be updated on the blockchain. This interface can be designed by future researchers and the idea can be taken forward. The stability of this network needs to be considered since we are going to connect them over a mass level.

Integration of Google Maps with these Autonomous cars can help us reduce the number of times the weight needs to be updated as google maps try to keep their artificial; intelligence updated. Privacy and Security will also be increased since we have Google as a backup. Further, the Scope of Digital Image Processing and Digital Communications whilst integrating these technologies could be future scope. Calibration with high accuracy is a must when we are replacing a human with a bot, so we need to make sure that the training models include all the possible scenarios that can come under dynamic conditions. We need to make sure that the training models are efficient and the blockchain technology that we have come up with is applied so as to increase the privacy and security of the company along with great infrastructure.

7. Conclusion

From a company's perspective, we were able to achieve great metrics and that they could be engineered and implemented. The time complexity was reduced to 1 where initially it was N (where N is considered as a number of cars). Furthermore, for communication and real-time data transmission, we considered blockchain technology for creating a hybrid network, which will allow users to help each other by sending updated weights. The Deep Neural Network (DNN) was implemented and its corresponding blockchain was created. This idea can be taken forward by engineers to interface these two technologies to avail the maximum out of it.

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