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Deep Learning for Steering Angle Prediction in Autonomous Vehicles

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Abstract

The fields of computer vision, image processing, and deep learning have seen exponential growth and advancement in recent years thanks to advances in technology. This renaissance has recently established itself as the dominant force in the field of automation. The ideas of image processing are easily applicable to the driving of automobiles, where the increasing sophistication of technology may one day make human drivers obsolete. However, the steering angle of a vehicle is the single most crucial component that comes into play when it comes to automation because this is what determines how the vehicle will take the curve. Automotive vehicles (AVs) have begun to take the steering angle prediction into consideration, and a large number of automotive businesses, like Tesla and Udacity, have also invested in the technology. Despite this, a significant number of researchers and insurance firms have shown interest in investing in this field. It has been determined that deep learning architectures are the most appropriate fundamentals that can be utilized in a situation like this one. As a result, this thesis suggests employing DL in order to anticipate the steering angle of autonomous vehicles. Image processing and CNN are the two components that make up the implementation, which is carried out in two separate modules. A collection of images are taken by the cameras that are mounted, and a steering angle is computed for each point along the path that the vehicle travels, taking into account the speed at which the vehicle is traveling as well as the amount of pressure that is being applied to the brake pedal. Image processing, which makes use of photos for the purpose of training, and data augmentation, which resizes the images, are both included in the first step of the execution process. The processed image that was obtained from the first phase is given as the input to the subsequent phase, and a predicted steering angle is generated as the output of this phase. The subsequent phase involves the use of CNN ideas.

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Introduction

In common parlance, "autonomous driving" refers to the operation of motor vehicles by means of a computerized system that does not require the participation or oversight of a human driver. To accomplish this, a computer "brain" must work in a manner that is analogous to that of a human brain. A machine, with the assistance of sensors, is capable of doing so and is able to drive a car under any and all conditions, just like a human driver. The idea that there should be no or only a minimal amount of human involvement in driving cars can also be extended to the field of aeronautics, where the pilot operates the aircraft in a manner that is analogous to driving while using auto-pilot. Deep learning is one of the common technological methods that can be used to create automated driving through the use of technology. By establishing intriguing qualities, such as

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being able to automatically learn complex processes exactly like humans do, deep learning makes it possible for automated driving to become a reality. After that, the machine does some more mapping of these complicated functions and increases their level of efficiency. In practical applications, qualities of this kind become significant and have critical bearing on the outcome. Image classification and identification is one of the areas that is utilized the most frequently in the demonstration of automated driving.

The majority of the most successful technology companies, such as Google, Tesla, and Honda, have already spent millions of dollars on autonomous vehicles [1]. Software and hardware are the two components that make up a typical autonomous vehicle. It receives data from a multitude of hardware sources, including cameras, sensors, GPS, radars, ultrasonic sensors, and Lidar, amongst others [2]. Knowledge of different domains is required for a variety of different hardware and software devices. It is hard for a single individual to develop a fully autonomous vehicle; doing so takes competence in a variety of fields, while it is conceivable to find a solution to a problem involving a particular functionality. Using the images of the lanes that are produced by a camera is one way that the challenge of forecasting the steering angle of the vehicle can be solved. The truck is outfitted with a camera that is capable of recording any conceivable item, as well as recognizing and categorizing the objects that it captures. This functionality is helpful in identifying humans, animals, and other objects in order to prevent a vehicle from colliding with the identified thing.

There has been a significant amount of research done on the topic of constructing an autonomous car; but what if the same paradigm were applied in low-cost hardware such as robotic vehicles? It is not possible that this would be a workable solution to the problem. The task of embedding a very complicated model, such as those used by Tesla and Google, into hardware that is either low cost or commodity grade is a difficult one. Because of this, the question that arises is, "Can an inexpensive model perform better than an expensive model when predicting the steering angle of a self-driving vehicle?" The developed model is rather simple and small in terms of its overall complexity. These models are easily capable of being incorporated into small-scale car platforms. These models have the potential to be utilized in warehouses for the delivery of goods, and more crucially, they have the potential to be utilized as a major instrument in the pharmaceutical and medical industries for the transportation of pharmaceuticals during pandemic scenarios.

Literature Survey

Deep learning is essentially a branch of the field of artificial intelligence, which has as its overarching goal the development of technologies that are capable of imitating human behaviour and achieving goals that a typical person would be able to accomplish. In a study done by [3], the author focused on the many different uses of deep learning that have led to the development of a wide variety of applications that are based on real life. One of these applications was focused on autonomous vehicles (AVs) and how the basics of deep learning may be utilized to achieve improved levels of efficiency. His work was further expanded towards automotive prediction of vehicle movements based on angular curves performed by the steering wheel. This aspect of his work was very important to the automobile industry.

According to the findings of a survey that was carried out, human mistake is the cause of ninety percent of all road accidents, while mechanical failure is responsible for only two percent of such incidents. These kinds of figures inspired academics to continue their work in the field of deep learning and develop real-world applications that could one day eliminate the need for human intervention in order for a vehicle to drive itself. As a result, this idea ended up being a contribution to the study that was done by academics working in the field of automated cars. It is possible that

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the development of a technology that might enable machines to take over driving tasks currently performed by humans and so prevent some of the deaths that occur annually as a result of traffic accidents. In the United States right now, there are more than 1,400 autonomous automobiles and trucks that are participating in the testing phase.

Fuzzy logic and deep learning algorithms were used to present the authors work in [4]. The writers offered their research study in an effort to identify the steering actions of cargo ships. The study was carried out with the use of a dataset from Udacity. The execution was carried out with the help of concepts from an algorithm that uses fuzzy logic. During this process, the authors highlighted specific areas along the trajectory and calculated their respective movements of the steering wheel throughout the course.

The authors of [5] presented the idea of using a genetic algorithm to identify the angular movement of the steering wheels of a vehicle. Their work was based on the ideas of deep learning, and the authors focused on the many layers that are involved in a standard CNN and how it helped towards the implementation of AV detection. [Their] work [was] based on [deep learning] concepts. The authors supplemented their work with other pre-existing genetic algorithm techniques in order to produce a more accurate model as a final product.

The authors of [6] presented a control system that was based on the concept of driving with an autopilot. An algorithm for managing deep learning was utilized here. Because of their efforts, an automatic detection of the steering angles of a four-wheeled vehicle was made possible. A fuzzy logic algorithm was also used, with its usage being determined by the model's fuzzy parameters. Multiple photographs were taken by the model, which were also taken by the cameras that had been deployed. Additionally, the accuracy of the model was increased by the authors by making use of assessment parameters.

Deep learning served as the conceptual foundation for research methodology for the entirety of his study. The primary emphasis of the model was placed on the incorporation of steering wheel prediction into autonomous vehicles. Additionally, the writers include information that is both comprehensive and succinct on CNN and the layers that are related with it. The author provided a synopsis of all of its operational layers, along with a discussion of its merits and drawbacks. He also discussed the framework of a model that uses deep learning and provided the many forms of algorithms that fall under the broad category of deep learning.

Methodologies Used

A Computer Vision

The term "computer vision" refers to a subfield of "artificial intelligence," which encompasses a considerably wider field of study. It grants computers and other machines the ability to view objects and extract relevant information from those visualizations, which in turn helps the model get closer to producing accurate answers. Digital images, in addition to sights, are both accepted as inputs by it [7]. This capacity of a machine is what gives it the ability to observe, think, and behave in the same manner as a human would do. The notion of computer visions operates in a manner that is comparable to that of human visions; nevertheless, computers do not have an advantage over humans in this regard. In general, the performance of computer vision is accomplished by deriving its functions from images captured by cameras that have been attached to the models.

B Image Processing

The act of processing an image by applying various methods and algorithms that are carried out on a computer is the fundamental idea behind image processing. It is a subfield of digital imaging,

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which involves the capturing of images and their subsequent processing through the application of various algorithms and methods of deep learning. In most cases, the computers are designed in such a manner that they are able to receive images as input from the camera and then process those images using many levels of algorithmic processing. The photos go through a process of resampling and scaling in order to conform to the output that is required during this application of algorithms. The latter stages involve converting all grayscale photos to their proper dimensions and working with them there. The idea of image processing, in general, refers to the act of processing a picture by applying particular modifications to the images, such as smoothing or sharpening. Processing algorithms are responsible for bringing about these changes. On the other hand, computer vision makes use of these image processing techniques and algorithms, as was described earlier, in order to recognize certain sections of digital images or particular characteristics contained within them.

C Neural Networks

Neural networks are a much larger component of networks as a whole. These networks are based on the idea of neurons and attempt to perform their functions in a manner that is analogous to that of the human brain. A neural network, like the human brain, is composed of neurons, and its goal is to learn to recognize different things and carry out various computational operations based on those things. This process is carried out in a manner that is analogous to the method in which the human brain shall function and operate. The neurons that are currently present in the network were formed in an artificial manner by mathematical computations that are able to adjust to the fluctuating nature of the neurons. Using this idea, the network produces the highest potential amount of output while simultaneously optimizing the results. Despite the fact that it may be traced back to the field of artificial intelligence, it has become increasingly common in the operation of a wide variety of real-world applications. After that, the working is continued by having the input layer take photographs as inputs and then generate appropriate outputs according to the requirements. Multiple hidden layers can be found in a neural network somewhere in the middle of the input layer and the output layer. The real processing of algorithms takes place in these layers through the application of activation functions and weights that are carefully considered.

D Deep Learning

Deep learning is a subcategory that falls under machine learning, which is itself a category that falls under the umbrella of artificial intelligence. Deep learning, on the other hand, is a subfield of neural networks, which are based on the idea of recreating the function of neurons in the human brain. Deep learning, as opposed to machine learning, which focuses solely on fundamental algorithms like random forest and KNN, requires a far deeper level of understanding. CNNs, RNNs, and ANNs are the main three hierarchical classifications when it comes to deep learning. CNNs, RNNs, and ANNs are the main three hierarchical classifications when it comes to deep learning. All of the algorithms that make use of the idea of deep earning function by executing several layers involved within it. This is how they get their results. There are many other variants that fall under each of the aforementioned three categories. These variants are employed in line with the application of the model that is intended to be used. A CNN structure is the type of deep learning algorithm that is utilized the most frequently. The following diagram illustrates how it is composed of numerous layers, which it does itself. On the other hand, its operation is analogous to that of neural networks, in that it makes use of linked weights and activation functions.

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Experimental Details

A Dataset Used

The most difficult aspect of the work that was done on the implementation was the collection of data and gaining access to the dataset. This was due to the fact that the paper offers to construct an affordable model for AVs. On the other hand, there were just a few repositories that were available and each one provided free access to the dataset of self-driving automobiles. The dataset included information that was gathered from the sensors that were put on the cameras. These sensors recorded a video that lasted for twenty-five minutes and contained images of the steering angles of vehicles.

The Commai dataset had a total of 80 GB of data. The analysis of this dataset was a little bit challenging. On the other hand, the dataset that was collected by Udacity consisted of seven hours of driving data and included information about the weather as a factor that contributes to the pattern changes that occur in the steering wheel angles. In addition to the angular data of steering wheels, the dataset that was hosted on Udacity also included information regarding the application of brakes and acceleration. On the other hand, it was discovered that a corporation based in China known as Baidu had contributed the most extensive dataset. They have access to an open dataset that explains everything there is to know about cars and vehicles that can drive themselves. The angle that corresponds to each image is depicted in the snapshot that can be found below:

Figure 1: Images of road captured by sensors

B Data Processing

The stage of data preparation is the step that will stand out the most in any model that is based on deep learning. The data that is collected from the dataset is comprised of a significant number of files that are based on either images or text. These files include information regarding the many angular positions that a car's steering wheel can be set to. Having said that, each of the files can be found in their respective folders. During the period of implementation, it is much simpler to make use of the Python library that automatically links the folders with their respective files than it is to manually update the path and link it to the files. This is because the Python library links the folders with their respective files. The dataset is stored in the primary repository, which consists of 45406 image files arranged in a single folder. The second file contains data that include photos of the angles of the steering wheels that were collected earlier. However, a text file that contains both photos and angles of the dataset that was obtained in this way is still a common occurrence. The testing and training step is repeated, and every file saves the corresponding paths and angles for that

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file. The degrees are used to store the angles that are contained within the dataset. In addition, these angles are transformed into radians in order to make it simpler for the neural network to analyse the visual input. On the other hand, activation functions like ReLu and Tanh can be utilized to delve even further into the network. Because of this procedure, implementing computational frequency on any model is now much simpler.

C Train and Test Set

The model is evaluated based on the data from the test set. When contrasted with the data used for training, the data used for testing have been created in an objective manner. Because the images were divided according to the time axis, there is no bias in either the train or the test data. It is necessary to compute performance metrics for each and every epoch, such as the root mean square error and accuracy. Calculations are done to determine the accuracy at each epoch as well as the average accuracy across all epochs. This section is broken up into subsections that compare the three different models with regard to the amount of time required for their training, the loss experienced during testing, the accuracy of their predictions, and the size of their models.

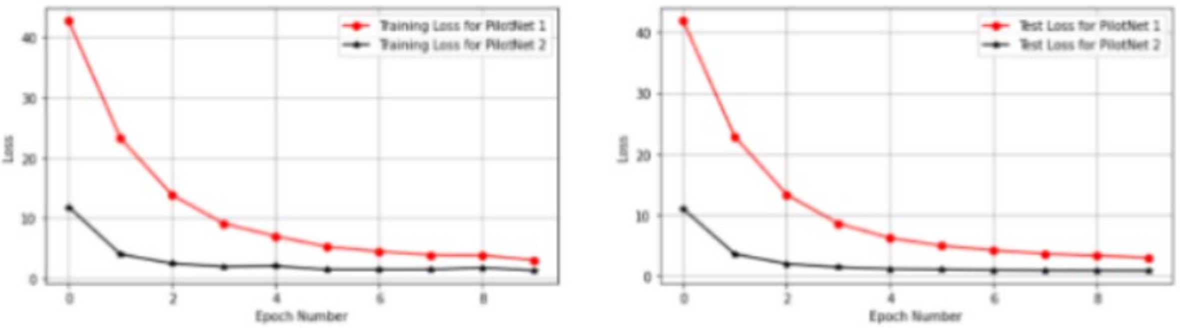

Figure 2: Train and Test Accuracies

The error that the model is making can be seen in the graph that follows. When the learning rate was slowed down, the model took a longer time to get closer and closer to the correct answer. At the beginning of the first epoch, the average test loss was somewhere about 24, but by the conclusion of the fifth epoch, it had dropped to about 23. This indicates that the model continued its pursuit of a local optimal solution, but at a more gradual pace. It's possible that the model might be successful if the number of epochs was raised, but training it on more than 30 epochs wouldn't require a smaller dataset.

Conclusions

Neural networks and computer vision play a significant role in the operation of autonomous cars. Object identification, the ability to anticipate traffic signals, and an accurate prediction of the steering angle are all included in self-driving automobiles. Image and video processing is the primary function of CNNs. Image classification tasks, such as identifying animals, persons, and other things on the road, are among the most prominent applications for CNNs. This investigation into estimating the steering angle is more appropriately framed as a regression challenge than a classification one. The primary objective of the research was to construct a model using deep learning that can estimate the steering angle of a vehicle. According to Agarwal et al. 2019, companies like Google Waymo, Tesla, and Uber have all made significant contributions to this field. The purpose of this study was to develop a deep learning model that is capable of predicting

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the steering angle of a vehicle at a reasonable cost and using all stages of the learning process. The creation of a system with lower operating costs would be beneficial to the automotive sector.

Following training with 0.0001, the model was trained and tested using 0.001, which is the default learning rate for the Adam optimizer (pilotNet-2). This resulted in a longer training period; however, the model was unable to pick up any new characteristics and hence performed poorly. Because raising the learning rate did not result in an improvement in the model's overall performance, the learning rate was slowed down. Because the learning rate was reduced to 0.00001 for the third trail (pilotNet-3), the training process for the model was lengthened, and it acquired knowledge of the characteristics at a more deliberate pace. It was trained for 5 epochs, and the error rate it produced was 20%. If it had been trained over a greater number of epochs, it would have required significantly more time to arrive at the best solution.

References

[1] Singh, S., Critical reasons for crashes investigated in the national motor vehicle crash causation survey. 2015
[2] Y. Kubo, G. Tucker, and S. Wiesler. “Compacting Neural Network Classifiers via Dropout Training.” ArXiv e-prints, Nov. 2016
[3] A. R. Diana Putri, Litasari and A. Susanto, "Comparison between colour models in automatic identification of cane sugar," 2013 IEEE International Conference on Computational Intelligence and Cybernetics Yogyakarta, 2013, pp. 146-150
[4] Kuutti, S., et al., A Survey of Deep Learning Applications to Autonomous Vehicle Control. Vol. PP. 2019
[5] H. Zhao, O. Gallo, I. Frosio and J. Kautz, "Loss Functions for Image Restoration With Neural Networks," in IEEE Transactions on Computational Imaging, vol. 3, no. 1, pp. 47-57, March 2017. doi: 10.1109/TCI.2016.2644865
[6] Eraqi, H.M., M.N. Moustafa, and J. Honer, End-to-end deep learning for steering autonomous vehicles considering temporal dependencies
[7] Islam, M.Z., et al., Self-driving car: a step to the future of mobility. 2018, BRAC University