Use Of Convolution Neural Network Algorithm For Implementation Of An Autonomous Vehicle

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Abstract: The whole world is switching to automation; the automobile industry is one of the types which has been focused on making an autonomous car. The Tesla and Audi are making the level 3 autonomous car. In the future, all the cars will travel without taking any human input. The proposed system develops an autonomous vehicle for transportation. In the proposed system it uses TensorFlow library, It is a high-performance numerical computation. You Only Look Once (YOLO) and Tensorflow is developed for machine learning and deep learning applications. The system uses a Convolution Neural Network (CNN) algorithm for training a network. In the proposed system workflow is starting from collecting and recording the real-time images and navigation inputs. In the next step YOLO algorithm detects the objects from an image by making the bounding box. Thirdly, these various images are processed in CNN and establish co-relation and stores in the database. Finally, in autonomous mode vehicle, all real-time images are compared with the stored image data for navigation and for obstacle avoidance. It comprises sensors, camera interface, radio communication, image processing (Open-CV), You Only Look Once (YOLO), Convolution Neural Network (CNN) (tensor flow). It can be a platform for further studies in Autonomous Vehicle (AV) domain and experiments.

Index Terms: You Only Look Once, Tensorflow, Convolution Neural Network, Open-cv.

1. INTRODUCTION

AUTONOMOUS vehicle senses the surrounding environment (objects, obstacles, pedestrians, etc.) and navigates without human input. AV are active research topic nowadays. Tesla, Ford, Mercedes-Benz, Audi started work on an autonomous vehicle. The applications of autonomous vehicles are to reduce mobility and infrastructure costs, increase safety, reduce crimes, traffic collision, and reduces the need for parking space.In the autonomous vehicle domain, there are many things which need to consider while making an autonomous vehicle. The traffic sign recognition, path planning, lane keeping, distance measuring between two objects, obstacle avoidance. There are various techniques used in AV like LiDAR [2] [11], RADAR, computer vision, sensors [7]. Traffic sign recognition is one of the parts of AV. Past traffic sign discovery method just gives bounding box of road sign as yield, and in this way requires additional procedures. To decrease this procedure another framework has been proposed where the position and exact boundary of road sign are anticipated at the same time [1]. Pedestrian's behaviors another challenge of AV [5]. Here AV recognizes the pedestrian behavior from its gesture, sample crosswalk with various weather conditions [5]. Testing is the most important thing in any research. For testing of AV [8] Open SCENARIO format is used. Experiments and test situations are produced for Testing and Validation process. Convolution Neural Network is a deep learning algorithm, using this algorithm authors proposed system created a different class of a network for AV. After creating a network, it distinguishes the different classes of signs (stop, go slow, etc.).GTSRB dataset is used for creating or training a neural network for road sign recognition [8].In the proposed system, Data is collected in the form of images taken by driving the vehicle on the road with actual weather conditions and the traffic. In proposed system CNN create a neural network of collected data and through these data it takes decision itself in AV.

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2 RELATED WORK

The previous system provides only bounding boxes of road sign as yield, it takes extra processes like shape estimation or picture division to get a limit of the sign. One of the drawback of the previous system is pixel level accuracy. Proposed traffic sign recognition framework forms the position and exact limit of traffic sign all the while [1].Autonomous vehicle recognizes the surrounding environment using LiDAR, RADAR techniques. This system divided into four steps. In the first step, LiDAR and camera obtains colorized laser scan, which collects shading and geometrical data. In the subsequent advance, three shading spaces RGB, HSV and CIE L*a*b* are joined with laser reflectivity. Thirdly, the 3-D geometrical qualities of organizer object that contains planarity, size and perspective proportion are used to decrease false alert. Last advance displays another virtual camera-based amendment procedure to blend fronto-parallel perspectives on a refined article in 3-D space [2].The system uses Convolution Neural algorithm for recognizing road signs. The role of CNN is to detect the contour of objects. The second layer combines the contours into objects further last layer uses this information to distinguish the objects i.e. to differentiate car object from a motorcycle. Training for CNN network uses GTSRB dataset, and achieves the best results of CNN. The overall accuracy of CNN is 99% during the test [8].

3 SYSTEM ARCHITECTURE

In the proposed system, detection of object is done with You Only Look Once (YOLO) algorithm and for machine learning, system uses Conversational Neural Network algorithm. The proposed system is divided into two modes as manual and autonomous.

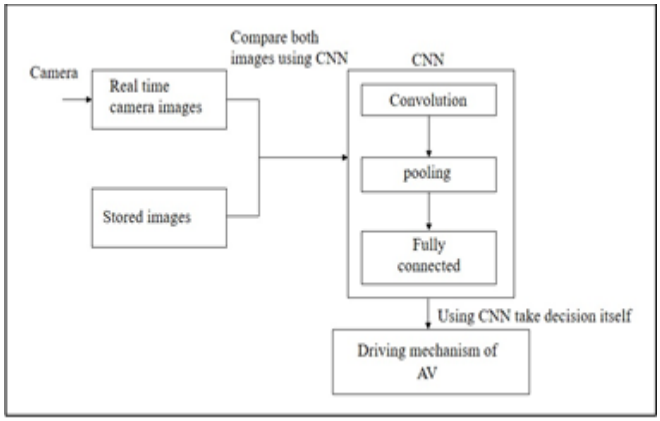

Fig. 1 *Schematic of CNN for an autonomous vehicle*

In manual mode, the system collects images and stores it in the database for future use. The system uses You Only Look Once (YOLO) Algorithm for object detection.In autonomous mode; system compares stored images with real-time images, and takes the decision itself.

4 METHODOLOGY

4.1 Methods of Data Collection

In the manual mode data are collected manually in the form of continuous images from camera. System records the actions performed during transportation or training. For e.g. Let a car is moving in front of vehicle or any ditch on road is coming from real-time road driving , then these activities are stored in database. In autonomous mode CNN algorithm sorts all captured image data useful for taking decision autonomously.

4.2 Convolution Neural Network Algorithm

The proposed framework employments the convolution neural system for establish the co-relation between images. CNN consists of five steps:

4.2.1 Convolution

This layer consists of a set of learnable filters. Convolution is the process of labeling the information signal by alluding to what it has realized previously.

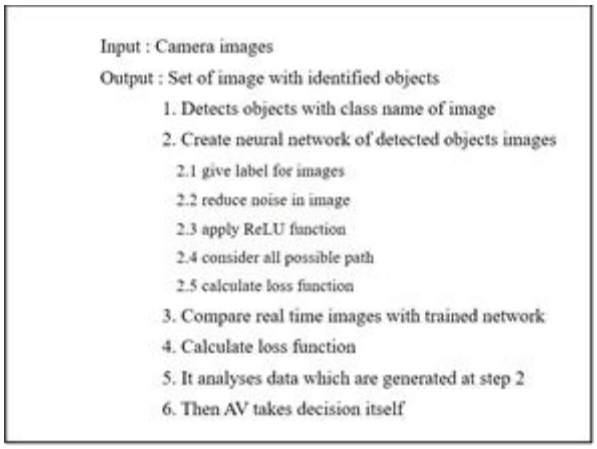

Fig. 2 *Steps of CNN*

4.2.2 Sub-Sampling

In this layer it reduces the noise of image which is passed by convolution layer. This process of smoothing is called sub sampling. The output of this step is a blurred image.

4.2.3 Activation

It controls how the sign streams starting with one layer then onto the next level; it is good with wide assortment of complex actuation capacity to display signal spread. The most widely recognized capacity is being ReLU, it stands for Rectified Linear Units. ReLU is often trains the neural system a few times quicker without a huge punishment to speculation exactness.

4.2.4 Fully connected layer

This layer perform abnormal state thinking in the neural system through completely associated layer. In this layer neurons are fully connected with previous layer, where every single imaginable pathways from the contribution to yield are considered.

4.2.5 Loss layer

This layer calculates the penalties in predicted output and the actual output. The role of loss function is to calculate the errors in neural network model. In the proposed systems loss function working flow is when object detection of image is done after that it creating a neural network for AV, during creating neural network the loss function role is to check the error in objects which are recognizes by YOLO. It gives criticism to the neural system on whether it distinguished info is right or not. This aides the neural system to reinforce the right concept. Loss layer calculates the difference between predicted output and actual output. Mathematically it is defined as

$$MSE = \frac{\sum_{i=1}^{n} \left(yi - \hat{yi} \right)^2}{n} \quad (1)$$

Where MSE stands for mean square error, yi represent prediction n is a dataset.

5 THEORETICAL ANALYSIS OF CNN

In this section Convolution Neural Network algorithm and You Only Look Once (YOLO) algorithm is analyzed. CNN is the unsupervised learning algorithm which is used in deep learning. Following section shows the actual process with real time example. In the proposed system images are captured from camera as shown in Fig. 5.1.

Fig. 3 *Image for processing*

System detects objects in image with YOLO algorithm. First step of YOLO is to divide an image in grid as shown in Fig. 5.2.

Fig. 4 *Dividing image into grid*

After dividing an image, confidence score is calculated as per bounding box, each bounding box have one confidence score. Confidence score is calculated by '$Object * IOU$' where IoU is Intersection over Union. Intersection over union measures of the overlap between two bounding boxes. In calculating IoU in the numerator it compute the zone of cover and in denominator is the region of association. Mathematically it is defined as

$$IoU = \frac{Ao}{Au} \quad (2)$$

Where the 'Ao' represents area of overlap and 'Au' represents area of union. The higher confidence score means the final output of that class. Next step is to form a bounding box around the objects as shown in Fig 5.3.

Fig. 5 *Bounding box for objects*

In the last step, class of particular bounding box is predicted with YOLO algorithm. YOLO have collection of '20' classes such as any object on the road like 'person', 'bicycle' , 'dog' etc. The final output of given image is shown in Fig 5.4.

Fig. 6 *Predicted class for an image*

All objects are predicted for particular class with YOLO algorithm. Role of CNN's starts after the detection of an object. First step of CNN detects the features of image such as faces, lines, and edges etc. Further algorithm reduces the noise present in an image with sub-sampling method. In the next layer of CNN, ReLU function is applied on image. ReLU stands for rectified linear unit it is kind of initiation work. ReLU is mostly used activation function in neural network especially in CNN. ReLU is used for train a neural network in less time. With ReLU function positive part is calculated i.e. only object related part is recognized. This is shown in Fig 5.4. With this only positive object parts like 'person', 'car', 'truck', and 'motorbike' etc. features are recognized. This function is called as activation function. Numerically, it is characterized as

$$y = \max(0, x) \quad (3)$$

Last layer of CNN is fully connected layer where all possible paths of inputs and outputs are considered. In this layer it connects previous layer so it is applied and tried to recognize the pattern of objects which are in current images. For example in Fig 5.4 it checks the previous layers results and learns the feature. Further final output is given in the form of an image. For checking the accuracy, CNN calculates the loss function which calculates the difference between predicted outputs and actual outputs.

6 CONCLUSION

Proposed autonomous electric car model is used for

transportation. The proposed system uses Convolution Neural Network algorithm (CNN) for making neural data and You Only Look Once algorithm for object detection in images. In this paper, YOLO and CNN algorithm are analyzed theoretically. Study of these algorithms shows that processing speed of CNN can be improved with addition of YOLO. CNN recognizes the objects with its features takes a decision automatically. This system is used for transportation of goods from one location to another in specific area. This reduces a manual work needed for transportation.

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