Curve Path Prediction and Vehicle Detection in Lane Roads Using Deep Learning for Autonomous Vehicles

G. Pavithra, N.M. Dhanya

Abstract--- There is always a huge demand for the development of the self-driving cars since they are the future of the autonomous vehicles. In the field of autonomous vehicles, problems still remains unsolved when there occurs any obstacle in the road lane while driving. In Self-driving cars, Lane detection is considered to be the most important part in reducing the number of accidents and risks. In this paper we have discovered the methodologies existing in the lane detection, the advantages and disadvantages of models. We have proposed a model that can detect lane in the straight and curved roads and detect vehicle existing in the lane. We have implemented a deep learning algorithm for the Vehicle Detection. The proposed methodology has been successfully applied to the dataset, the results are recorded and the performance metrics are tabulated. We have also discussed on the future scope of the Lane detection.

Keywords--- Lane Detection, Deep Learning, Convolutional neural network.

I. INTRODUCTION

With the increase in the number of vehicles and the enormous traffic in urban areas, the traffic safety becomes the priority. According to the recent survey in Indian Business Standards, Road accidents lead to 3 deaths every 10 minutes in India. There founded to exist Road accidents every minute in the country and it counts to 16 accidents per hour and also discovered that a total of 4, 64,910 road accidents were reported by states. Two wheeler account for 33.9% of total road crash deaths. On considering the factors contributing to these crashes in both Open roads and the Urban, Leaving the lane causes about 30% of accidents, and the reason for majority of these accidents are due to the carelessness of the driver and lack of lane warnings and the lane markings. These accidents are avoidable if there is a proper lane departure warning system. Therefore, such system that could provide a alert to the drivers about danger have a great impact to save more lives.

The lane detection starts from lane markers in a complex environment and is used to estimate the vehicle's position. At the same time, lane detection has a major role in the lane departure warning system. The detection consists of the localization of certain important aspects such as road markings. The main challenges lies in the parked and moving vehicles, Bad quality lane lines or no lines at all, Shadows that exists because of the trees, Improper parking of vehicles, irregular shape of lane, merging of lanes, sharper curves, improper pavement material and dissimilar slopes and the unnecessary humps in the road which causes problems in lane detection.

The application of a lane detecting could be directing the lane for the driver, giving alerts or warnings, identifying lane markings, identifying vehicles that already exists in the lane, stating different road marking such as white lanes, yellow lanes to more complex tasks such as finding any lane change is needed, vehicle position change, speed control according to different lanes etc.

There have been major research and improvements on the vehicle detection and the detection of lane. Many algorithms have been invented for the detection, giving alerts and tracking techniques. Many methods have been invented and tested for lane detection, which can be classified as either feature-based or Model-based. Feature-based methods detect features of the lane from the given input through edges of the lane. The feature-based methods lie on the clear lane-markings, but find it so tough for the improper lane markings or edges. Model-based methods useful for curve model. The model based approaches couldn't be applied to weak lane features when compared to feature-based methods.

The aim of this paper is to find various techniques for detecting lanes while minimizing the road accidents, understanding and applying suitable algorithm for the vehicle and lane detection for the dataset.

II. RELATED WORK

The lane detection can be done using various approaches such as the Feature-based; Region-based; Combination of the both, etc.

Feature Based Lane detection

The feature based detection of lanes is based on the extraction of the necessary features from the input image to detect the edges and the lanes. The feature detection model is further subdivided into Edge detection approaches [1] and Hough transform based approaches. The feature also detects the lane through the boundary lines in the input image. B. M. Broggi in his paper proposed a model that will detect the road lane lines using the edge detection approach and this model takes the input image and remaps into a new image which represents a bird eye view of the road and detects the lane marking. The advantage of this model is that it can find the lane markings even having Darker Background environments. Assidiq [2] proposed a method that uses the Canny edge detector for detecting the edges.

Manuscript received February 01, 2019

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It performs well even in shadows. It was suitable for both curved and straight roads. Z. Kim [3] proposed a model that used Edge detector and intensive bump detector for the Pre-processing. The model used artificial neural networks (ANN) for the detection and the particle filter for the Tracking of the lane. This model was proven to be working well even in the presence of the low illumination. It was tested in both the Curved and the straight roads. P. Daigavane [4] in his model used canny edge detector for Pre-processing and Ant Colony Optimization for detection and line detection is done through the Hough transform. It is not robust for shadow road lanes.

Region based Lane detection

The region based lane detection method is further divided into Texture based, Color based detection approaches. The model works on focusing the major difference between the lane lines and the non-lane line regions such as separating the lane lines needed using the Boundary approaches thereby eliminating the non-road, non-lane regions. *Basic Process of* Region Based Lane detection is done byExtracting features to initialize lane markings such as edges, color, and other features from the image then processing the features extracted to remove outliers. In the obtained detected lane marks it does Tracking using a filter. (TFALDA)[5]Method uses both the boundary and the extraction method which is based on the boundary, starting position, direction and the gray level features. This method is tested in the real time environment which involves it calculates the minimum distance using the three important features mentioned above and then moving towards that lane. Kuo-Yu Chiu[6]proposed a model that is used for the structured roads which involves the Color based lane detection. It works based on the lane markings which uses least square method for the lane detection and the lane extension. It is useful in detecting in the Light environment but not in the darker background.

III. BACKGROUND

Our implementation of vehicle detection is done through the CNN and the lane detection is done through the Open CV.

Convolutional Neural Network

Convolutional Neural network (CNN) is a Deep learning algorithm which is used for the less Pre-processing. Towards the image recognition and the video recognition, CNN performs better than the other algorithms[7, 8]. CNN has main scope towards the image and video dataset than the text data [9]. CNN has mainly an input layer, output and the set of these multiple hidden layers. CNN generally has convolutional, pooling layer, fully connected and the flattening layers. It can have more than one Convolutional layer.

Computer Vision

Open CV (Open Source Computer Vision Library) is a library used for the computer vision. It optimizes the performance and increase the efficiency in the real time environment.

IV. PROPOSED METHODOLOGY

- Detecting lane in straight and curved roads.
- Detecting the vehicle in the detected lane roads
- Predicting the curvature of the lane and giving warnings when vehicle exists in the lane road.

Detecting lane in straight and curved roads

The lane detection mainly has three major steps: Pre-processing, Edge detection and then the line detection. However, the issue in the development of lane detection system is that the road traffic environment which is so tedious to predict. In the complex traffic environment where vehicle moving rate is high and speed is fast, the probability of road accidents are greater than usual.

Pre-processing

The input an image or video of the road obtained from the NYC traffic data is fed into the model. We propose a method that involves Pre-processing twice such that the noise is eliminated and the data can be easily detected. The input video is converted into frames. The frames captured is converted to gray scale image in order to reduce the processing time and segmented to binary image. The frames are then converted to gray scale. We do both the HSV Saturation and the RGB to gray scale conversion for the better accuracy. The Presence of noise in the image will obstruct the accurate edge detection. Thus, the image has to be applied to filters to remove noises. We use different filters bilateral filter, Gaussian filter, Gabor filter for such processing

Detection

Edge detector produces an image after filteringand result the edges. Then image is fed for further line detection which will find the right and left lane boundary. The boundary in the lane uses the detail that is obtained in the edge detected. This in turn returns a series of points on the both the sides.

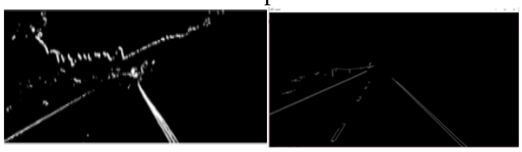

Fig. 1: Edge detected using the canny edge detection

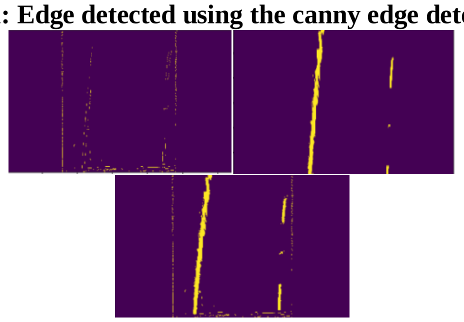

Fig. 2: Obtained Lane after the ROI, Transformation, Line detection and Masking

Detecting the vehicle in the detected lane roads

Training Data

The vehicle detection is implemented through the CNN (Convolutional Neural Network). The training input images are fed into our network. The model first does the normalization while normalizing the data to the same scale approximately.

We do Batch normalization here to our dataset. We add a lambda function to the model defining our function. The model is built with 6 Convolutional layers. We have an input layer, hidden layers (Convolution2D, MaxPooling2D and Dense) layers. We add a flattening layer to feature into 1D feature vector. The feature extraction is done using the DNN Classifier and the results are observed.

Detecting Vehicles

Then the input video is fed into a sliding-window technique that uses the trained classifier to search for vehicles in the input video frames.

We have created a heat map of detection frame by frame to reject outliers. Finally we result having a bounding box for vehicles detected.

Predicting the curvature of the lane and giving warnings when vehicle exists in the lane road

After filtering the lane lines with the morphological operations and detecting the lane with the edge detection algorithm we have got the resultant lane line.

In the resultant lane we will find the left lane and right lane using the center point of the lane and fit the lane line using the triangle region.

Then we determine the curvature of lane from centre of the lane. From the previous detection, if any vehicle exists in the lane a warning will be given to the system to change the lane.

V. IMPLEMENTATION

Datasets

The Dataset for the Vehicle detection was obtained from Stanford Cars Dataset from Kaggle, GTI Vehicle image dataset and KITTI dataset (obtained from the roads of Germany)[10-11] which is used for the 3D Object detection. The dataset is of Image Format. The dataset contains vehicle and non-vehicle data that comprises of 9500 Images of size (64x64 pixel).

We split train the model with 7600 images and validate the dataset with 1900 data. The vehicle dataset contains the vehicle's Front view, Back view and side view. The dataset also contains the Non vehicle data that includes the street, pedestrian, etc.

The input data is fed into the feature extraction method which generates the output data that has to be fed into our network

Fig. 3: Dataset containing the vehicle and non-vehicle data labeled individually

The Dataset for the lane detection is a video which has both Straight roads and the curved roads. The dataset is taken from NYC Traffic database. The dataset is of Video Format which is converted into frames for processing.

VI. PERFORMANCE METRICS

We evaluate the performance metrics of lane detection algorithms by comparing the results with ground truth data and then check if there exists true positive (TP) or false positive (FP) or false negative (FN) or true negative (TN).

- TP is when ground truth exists and lane is successfully detected by the model proposed.
- FP is when method detects the lane roads even when there exists no ground truth.
- FN is when there exist a ground truth and the method fails to detect.
- TN is when no ground truth exists and algorithm fails to find the lane lines.

The Metrics used for performance evaluation are the standard methods such as Precision, Recall, and Accuracy.

$$Precision = TP/(TP + FP)$$
$$Accuracy = (TP + TN)/(TP + FP + FN + TN)$$
$$Recall = TP/(TP + FN)$$

Fig 4: Equations to evaluate Performance metrics

VII. RESULT

The CNN was implemented on two different dataset collected from the Stanford and the GTI image dataset for the vehicle detection in the roads. The training set contains 80% of the data and we validate the result with 20% of the data and the performance metrics is tabulated.

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Table 1: Performance metrics of Dataset I trained on CNN

Algorithm	CNN (Dataset I)
Accuracy	0.8355
Precision	0.1646
Recall	0.6310

The Dataset I is the GTI dataset which has the image of pixel (64x64) is fed to the network and the results are tabulated in Table 1. The Dataset II is the collection of mixed set of images collected from different database (Stanford Cars Dataset from Kaggle, GTI Vehicle image dataset and KITTI dataset) and the input is fed to the developed model and the results are tabulated in Table 2.

Table 2: Performance metrics of Dataset II trained on CNN

Algorithm	CNN (Dataset II)
Accuracy	0.7697
Precision	0.2987
Recall	0.5231

VIII. CONCLUSION

In this paper, an analysis of lane detection algorithm is brought to discussion. The methods used and proposed for lane detection, the challenges and the future scope and their performance metrics is also presented in the paper. Even though various new methodology has been implemented in lane detection, still problem exists. Most of these problem occurs when in poor environmental condition when it fails to detect or in the curvy roads where detection is too tedious. The future scope of the lane detection includes complex environment taking into account the different environments such as the Weather conditions: fog, mist, cloudy, sunny, bright day light, darker, shadow or when there occurs obstacles and Humps, Speed Breakers in the Road. The study shows that the CNN performs better in the vehicle detection. In the lane detection, the observed results show that the more Pre-processing is done the more the accurate possibilities of detection in regards to the accuracy, precision and recall calculated.

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