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ASSESSMENT OF SOFTWARE STACK FOR SELF DRIVING CARS FOR INDIA

Sri KrishnaUppili[1], Keerthivasan S[2], Kilari Prudhvi[3] and Dr. Radha Senthilkumar[4]
[1,2,3,4] Madras Institute of Technology, Chennai, Tamil Nadu, India
{srikrishnauppili,keerthishan123,prudhvikilari007, radhasenthilkumar}@gmail.com

Abstract— *Self driving cars are a major research topic and innovation in the artificial Intelligence field. But there are many limitations for implementing it in Indian roads. The faded lanes, wandering of animals, improper lane usage by drivers, improper footpaths, different driving practices, inconsistent drivers makes it difficult to implement in India. The government also does not allow usage of self driving cars in Indian roads. The software stack proposed in this work will help to create a robust self driving vehicle for Indian roads. The paper explains the steps involved in the development of the software, additional classes and modules to be merged in the existing software stack to work efficiently for Indian roads.*

Keywords — *Software stack, Self driving Vehicle, Autonomous cars, India roads*.

I. INTRODUCTION

The complete software stack required for self driving cars for India is analyzed and different challenges are highlighted. The software stack includes Perception, Prediction and motion Planning modules. The perception module is the part of the software stack which deals with all detection on the road. Some common detection include obstacle and pedestrian detection, road sign detection, vehicle detection. The prediction module acts as the core brain of the self driving vehicle (SDV). It takes important decisions of how the SDV should react to different scenarios. Examples of tasks prediction module performs include identifying trajectory of pedestrian, Intention prediction of vehicles. The motion planning part deals with directing the vehicle across a particular direction. The paper deals with the special features needed to implement self driving cars in Indian roads and explains about the implementation of three major modules required for the software stack which include Behavioral cloning, Lane detection and Road sign detection. Some additional modules specific to India like horn sound classification are also discussed.

II. SELF DRIVING VEHICLES IN INDIA

As an emerging technology, artificial intelligence has its fair share of advantages and disadvantages. By studying more about the pros and cons of artificial intelligence, we can decide on how artificial intelligence can be integrated with electrical engineering in orderto facilitate a smarter system.

A. Problem statement

The problems for developing self-driving cars in India include non-existent road markings, potholes and poorly maintained footpaths. The existing products are based on correct alignment of lanes and proper environment conditions and do not cover many features specific to Indian roads. For Indian roads, changes needed in the software stack includes change in dataset collection, model architecture, prediction modules, traffic rules, common road practices, horn sounds. These attributes should be embedded into the software stack to create a robust SDV for India.

B. Scope

At present for creating a self driving car there are a large number of milestones to achieve which includes creating separate components for prediction, perception and motion planning. A large amount of development time would be wasted for each component to set up for Indian roads. The proposed system can be used as a base line module to boost self driving car development. These modules help the developers to focus more on the advanced development features rather than focusing on each new class specific to India.

C. Need for self driving vehicle in India

There would be a huge demand for self-driving cars in India due to the busy population and congested roads, so people can do their work even while driving. According to statistics by Udacity [12] there is a high need for self driving cars in India, but the government regulations and high population of the country makes it difficult to set up a self driving car in India. The Indian Motor Vehicles Act, 1988 and the rules that regulate operation of vehicles in India, does not currently allow fully automated vehicles to drive in Indian roads. A human driver should be driving the vehicle with full control of the vehicle at all times. Thus even testing of self driving cars in India is a difficult task. But software stack specific to Indian roads can be created, to be used in the cars in future after suitable conditions are established in India. The software stack being developed should be able to follow India specific road rules. Some common driving practices include always overtake a vehicle on the right side of the vehicle, keep speed limit at specific regions. No strict lane system practices are followed, so more deep learning training should be done to understand the intent of the drivers in the road. The most common practice followed by Indian drivers is communicating through honking. The software should be developed to understand and follow these practices.

D. Classes covered

Potholes, streetlamps, animals, Indian vehicles are some classes required specific to Indian roads. Some common classes include stray animals like cattle, dogs, India specific vehicles like water trucks, modified cars, Streetlamp, road blockers. These special classes should be included in the data set for training the deep learning model. The scenarios which need to be considered include wrong side drivers, inconsistent drivers, construction works, Types of horns, siren sounds. The self driving vehicle should be able to recognise the scenario and take corresponding actions.

E. Road actors

The road actors are the kind of obstacles which cross the self driving car. The road actors include Jay walkers who come in front of cars without following traffic signals, Opposite lane actors who tend to move in a wrong direction in the road and self driving cars may not recognize them and take corresponding action. The self driving vehicle should be able to differentiate stationary vehicles and moving vehicles in roads to adjust speed correspondingly and should also recognize street animals like cattle and also predict possible trajectory to make correct decisions while driving.

III. CONTRIBUTION

The challenges involved in deploying self driving cars in India are analyzed and special features required specific to Indian roads are identified. Some of the additional modules in the software stack required for Indian roads are analysed which include horn sound classification, faded lane detection, intent prediction. The steering angle prediction network is analyzed, modified and a comparative result was obtained. Regularization function and additional dropout layers were added to avoid overfitting. Different methods were analyzed for gathering data of steering angle corresponding to Indian roads. In Lane detection instead of directly processing the image taken from the camera, undistortion of input images was done to avoid the distortion. To address the parallel merge problem, the top view of the image was taken using perspective transformation. This helps to produce a more reliable output. As a next step instead of directly applying edge detection techniques, combinations of techniques were analyzed and the best possible combination was chosen. The result of the combination of sobel with color thresholding techniques is more reliable as it detected the lanes more clearly. For traffic sign detection, additional images of road signs were collected which are specific to India. These signs are used for training of the model. The trained model can be used for Indian roads.

IV. RESEARCH CHALLENGES

A. Visualisation

The software stack needs to be deployed in a simulator to be able to visualise the results obtained. But there are no Indian simulators for visualising the India specific obstacles, rules and scenarios. Hence in the proposed work, the Udacity simulator is modified through Unity platform by adding Indian specific obstacles and scenarios.

B. Bias of driving straight

For steering angle prediction, the dataset contains image frames and corresponding steering angles. But these data are generated from real time vehicles by monitoring the steering wheel angle while driving. Most of the vehicles tend to drive in a straight angle except there is a left or right turn. Thus in a model trained using this dataset there is a possibility of bias of driving straight. Hence the dataset is preprocessed by removing straight angle to equalize distribution of steering angle.

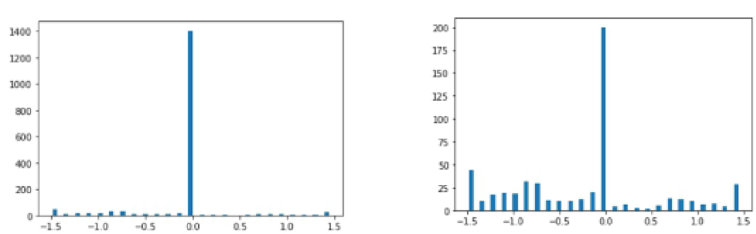

Fig.1 Steering Angle Bias Removal

C. Indian road rules

The software stack being developed should be able to follow India specific road rules. Some common driving practices include always overtake a vehicle on the right side of the vehicle, keep speed limit at specific regions. No strict lane system practices are followed, so more deep learning training should be done to understand the intent of the drivers in the road. The most common practice followed by Indian drivers is communicating through honking. The software should be developed to understand and follow these practices.

D. Dataset collection

The dataset for steering angle prediction needs to be created by adding a special hardware to the vehicle and riding it across roads, so only limited resources are available. Hence for training the model, the data set was generated using Udacity simulator. Using Unity software existing simulators can be modified by adding additional data for simulating Indian roads, but frames are in animated form hence could not perform well in real roads. Hence the best way to collect data is to add necessary hardware to vehicles and get data from real time.

V. IMPLEMENTATION

A. Steering angle cloning

Steering angle prediction plays an important role in a self driving car. It helps to clone the behaviour of the driver, thus the self-driving vehicle will be able to react to potholes, barricades, and adjust steering angle automatically. Using Steering angle cloning, it will be really useful for deploying to Indian roads, since all special features specific to Indian roads like cattle on road, road condition will be trained all together in this single network architecture. The major problem in lane detection which is faded lane can also be addressed using this module. Since the entire behaviour of the driver is cloned, the vehicle could be trained to react to all obstacles and also move on roads without lanes. But for Indian roads, there are some challenges for deploying this module. The major challenge is the data collection. It is difficult to identify all possible classes of road obstacles and features and cover that in the dataset because Indian roads change dynamically. Some common features with respect to Indian roads include cattles or other stray animals crossing the road, Construction works happening in between roads, a special kind of old fashioned vehicle, pedestrian crossing road in places where there is no signal or zebra crossing, trees on side road, towers and transformers, vehicles parked on side of the main road hiding the lane, inconsistent drivers who don't follow specific lanes. The dataset created for Indian roads should cover all these special features to work without any problem. In India roads, there is possibility that roads get flooded during rain, view gets covered with fog in morning, heavy smoke in high traffic areas. The steering angle prediction modules should be able to cover all these challenges.

B. Road sign detection

Road Sign Detection is a major module in autonomous vehicles which helps the self-driving car to follow road rules. Road sign detection module is done using Convolution Neural Network (CNN).The road sign detection has two main stages involved. Image is acquired to perform preprocessing, then the extracted sign area is classified by means of automatic features extraction with deep CNN. In the second stage of the system an improved model based on the YOLO model is created. The experimental results give an accuracy of 97%. The trained model works great for Indian based road signs and also recognized occluded traffic signs successfully.

C. Lane detection

In most of the developed countries the existing lane detection techniques work because the highways are well paved and have lane markers which can be captured through the camera. But they don’t work on India as there are many places where there are no distinct lane markings on the road. Also there are some

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areas where there are faded lane markings or no markings on the road. Even some of the highways have faded lane markers. Even using a high quality camera these lines can't be captured as they are faded to great extent. As the existing methods involve finding the lanes it won't be able to distinguish the drivable part of the road if there are no lanes. This can be solved by using segmentation of the road. This involves finding the drivable part of the road. This also helps us to find the moving objects ahead which helps us to predict the path of the car. By using segmentation of roads on the lanes which have no markings the self driving car will create its own path. Thus by this method a lane detection software can be made for the self driving cars in India. There is another major challenge for deploying lane detection in Indian roads. The vehicles do not follow the lane practices. Thus travelling just by following the lane lines is not feasible for Indian roads. Thus an additional module for vehicle intention prediction should be merged with the existing software stack.

D. Horn classification

Horn sounds play an important role in Indian roads for communication between vehicles. Horn sounds are used in many scenarios which include before overtaking, for asking to give way, to inform opposite lane vehicles at sharp turns, emergency purposes. If the horn sound can be classified, it helps the SDV to understand the scenario much better. Other kinds of communication between vehicles include blinking of headlights. If both horn sound and blinking of light are classified the self driving vehicle can easily adapt to the Indian roads. The classification module can also be extended to classify types of vehicles based on vehicle sound. This can be useful during sharp turns where SDV cameras cannot cover the road. The type of vehicle can be detected and take corresponding action like stop when it is a big vehicle or proceed when it is a small vehicle.

E. Mapping

Self driving cars need a large number of data about its surrounding regions. So HD maps are being used which include centimeter level accuracy data. It helps to maintain lanes and assess distance between objects. For Indian roads, the maps need to be created which is robust enough to update to the dynamic changing road condition of India. The possible way to create HD maps for India is to create a software module to be deployed in a drone. The drone can move through an area and create maps with greater detail.

F. Operational domain

Operational Domain Selection deals with the possible locations where self driving cars can be deployed. There are some special features required to ensure proper operation of a self driving car. Some required features include proper lane lines, Proper road dividers to prevent people suddenly crossing the roads, less pedestrian population, available traffic signs on roads. These features are needed to start basic testing on roads in India. The Fig. 2 shows a sample operational domain in Chennai which satisfies the required condition for safe testing of self driving cars in India.

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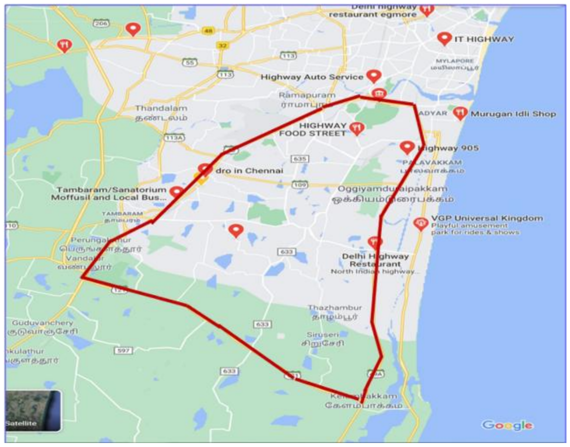

Fig.2 Operational domain in Chennai

G. Dataset used

The dataset used for steering angle prediction includes real time road video frames and corresponding steering angle data for the frame. The dataset used for training is from [14] which gives 7 and a quarter hours of driving data. For road sign detection the dataset is used from [10], and additional images containing Indian road signs are added to the dataset. The total data used for training the road sign detection model includes 43 classes with 50000 images. For lane detection the lane lines are detected using advanced image processing filters.

VI. TECHNICAL DETAILS

A. Steering angle prediction

The steering angle model architecture is modified where ELU is used as activation function to solve the dying Relu problem, and implemented Dropout and L2 Regularization. Implemented preprocessing steps in the input image. The preprocessing steps include cropping images to remove unwanted features, change to YUV image, apply Gaussian blur, normalize values and decrease image size. The steering angle dataset is processed to remove bias of driving straight.

B. Lane detection

The image taken from the camera is distorted. They are undistorted using the openCV package. The undistorted image can't be used directly for lane detection as it may cause parallel line merge problem. To avoid that, the top view of the image is created using perspective transformation. The transformed image is used for detection of lanes. Using a combination of color thresholding techniques as proposed in [15], the lane is detected. Sliding window approach is applied over the detected lanes to find the curvature of the lane. A small frame is constructed over the lane and based upon the curvature of the lane the frame is shifted .After identifying the curvature the path for the car is detected.

C. Road sign detection

Road signs specific to India are collected to form an Indian road sign dataset. For detection of traffic signs, different algorithms were analyzed. Preprocessing techniques including Data Augmentation, Histogram Equalization and Grayscaling were applied. The CNN is trained with the collected Indian road sign dataset.

D. Horn sound classification

Two classes of horn sounds are covered which include "Overtaking" and "Give way". These are classified using the time period of honking and sensor data of the position of nearby vehicles. Using these data the purpose of horn and action need to be taken can be decided. The horn sound is identified and processed as explained in the paper [11]. The processed sound is used to classify the horn and give corresponding output.

VII. RESULTS AND COMPARISON

A. Steering angle prediction results

The different model architecture results analysis and output visualization is shown in Fig. 3. It is observed that the resnet architecture gives better results when compared with the original model. The output visualization shows the steering angle rotates right when the road has a right curve.

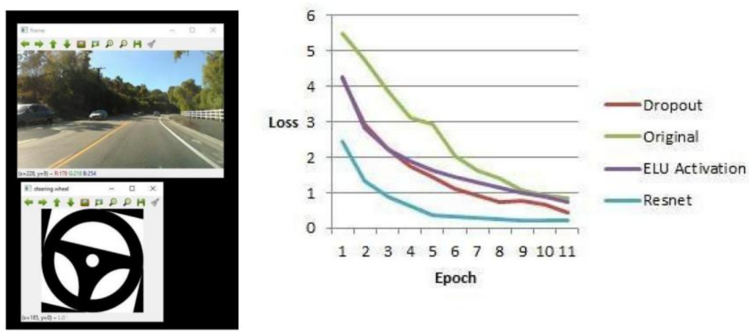

Fig.3. Steering angle visualisation and loss comparison curve

B. Road sign detection results

An image containing a give way sign was given as input. Fig 4 shows the predicted output and preprocessed input image of the road sign.

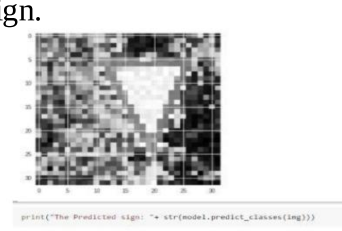

Fig.4 Road sign detection result

C. Lane detection results

An input video is given to detect the path of the lane on the road. The video is separated frame by frame and each frame is passed to detect the lane. The Combined threshold values are applied and the lanes are detected from the image. The curvature of the road is found and then the path is detected from the amount of curvature. Thus the complete path is detected for the movement of the vehicles based on the openCV method. Fig 5 shows the comparison between sobel detection of the lane and combination of color thresholding channels. The Combination of color channels with Sobel used for detection produced

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great results when compared to detection using only sobel operators.

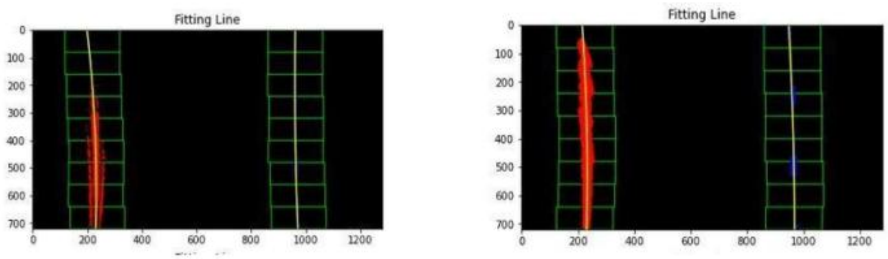

Fig.5 Lane detection comparison

VIII. Conclusion

Self driving cars are not yet designed to run on Indian roads. The car companies are competing to get into the field of self driving in India. This software stack will be really useful for the companies to make self driving cars for India much easier. The basic modules necessary for deploying self driving cars in Indian roads are analysed. The challenges that are present in deploying software stack for Indian roads is discussed. Steering angle is predicted using the modified model architecture and a comparison is done with the existing system. Lane lines were detected using a combination of color thresholding channels which identified the lanes more accurately. Indian traffic sign dataset is created and a traffic sign prediction module is created with an accuracy of 97%. The future work to be done include adjusting steering angle, speed and other data of the vehicle based on the detection made by other modules and perform motion planning using HD maps to obtain a good route to be taken automatically.

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