Real-time Robust Lane Detection and Warning System using Hough Transform Method

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Abstract- **Many people die each year in roadway departure crashes caused by driver inattention. Lane detection systems are useful in avoiding these accidents as safety is the main purpose of these systems. Such systems have the target to detect the lanes and to warn the driver in case the vehicle has a tendency to depart from the lane. A lane detection system is an important aspect of many intelligent transport systems. Lane detection is a demanding task because of the varying road conditions that one can come across while driving. In the past few years, plentiful approaches for lane detection were proposed and successfully demonstrated. In this paper, after a brief overview of existing methods, we present a robust lane detection based on Canny edge detection and Hough transform method.**

Keywords— Canny Algorithm, Edge Detection, Feature Extraction, Hough Transform, Lane Detection, Region of Interest(ROI).

I. INTRODUCTION

Now a day the road accidents have increased to a great extent. Most of the accidents occur due to driver's negligence and carelessness while driving. Advance driver assistance system (ADAS) plays an important role in providing safety to drivers. It helps to automate the car system and increases the driving experiences. The Advance driver assistance system (ADAS) provides a safe system to reduce the road accidents. The system takes an vigorous step like warning the driver or takes a corrective action to avoid an accident during the risky situation.

The Lane Departure Warning (LDW) is an important unit in Advance driver assistance system. In vision based lane departure system, a camera is placed behind the wind shield of the vehicles and images of the road is captured. The white stripes on the road are interpreted and lanes are identified. Whenever the vehicle goes out of the lane then the warning is given to the driver. In lane departure warning system, the lane detection is the primary step to be taken.

There are two types of approaches used in lane detection: the feature based approach and the model based approach. The features based approach detects the lane in the road images by detecting the low level features such as lane edges or highlighted lanes etc. This approach requires well highlighted lines or strong lane edges, otherwise it will fail. This approach may suffer from occlusion or noise. The geometric parameters such as assuming the shape of lane can be presented by straight line or curves are used by the model based approached.

II. LITERATURE OVERVIEW

Most of the time accidents are caused by lack of concentration and not maintaining a safe car distance to the car in front, or changing lanes without paying attention for vehicles which is next to the car. This project is about detecting the boundaries of the lane and to tell the driver if he/she is going to change the lane without signifying for his/her intention. The system should also try to measure the distance to the vehicle in front of that vehicle and signalize if the distance in not safe enough.

Lane detection in driving scenes is an significant component for autonomous vehicles and advanced driver assistance systems. In recent years, many complicated lane detection methods have been proposed. However, most methods focus on detecting the lane from one single image, and often lead to unacceptable performance in handling some extremely-bad situations such as heavy shadow, severe mark degradation, serious vehicle occlusion, and so on. In fact, lanes are incessant line structures on the road.

Vehicle safety plays an important role for safety of all road users and also useful to measure the crash avoidance or reduction of injury. The purposes of Advanced driver assistance systems are to reduce the risk and assist post impact care are also investigated for future application.

Table 1: Literature Survey

Sr. No	Paper Reference No.	Year	Methods Used	Advantages	Accuracy
1.	[1]	2018, IET Jour.	CNN, pre-processing, feature detection, fitting tracking, kalman filter, particle filter.	It gives high accuracy. Better results for detecting curved lanes.	98%
2.	[2]	2018, IEEE	Feature extraction, model fitting, Random Sample Consensus (RANSAC) technique	Better computation efficiency, High accuracy	-
3.	[3]	2018, IEEE	Principle Component Analysis Technique	Real-time performance within a low computation hardware platform	-

4.	[4]	2018, IEEE	Median strip detection approach, Lane change detection approach	Smart use of spatio-temporal information provided by the embedded sensors technology	-
5.	[5]	2018, IJPAM Journal	Review paper	-	-
6.	[6]	2018, EURASIP Journal	Hough transform and Kirsch operator, feature extraction	the robustness and adaptability of the detection results are enhanced, the computational complexity of the algorithm is reduced by the matrix operation.	-
7.	[7]	2018, Hindawi Journal	Kalman filter, Hough transform, Feature extraction, colour extraction	Better accuracy and faster processing speed	95%
8.	[8]	2017	LDWS Algorithm, Canny's Algorithm, Hough Transform Technique	High accuracy and robustness against noise and model imperfection	-
9.	[9]	2017, IEEE	Canny edge detection algorithm, Hough transform Method	Faster processing speed	-
10.	[10]	2017, IEEE	Gabor filter, Hough transform method, Sobel operator, least squares algorithm	System is real-time, efficient and enhance the adaptability for the changing environment of road scene.	93%
11.	[11]	2017, IEEE	Spatio-Temporal incremental clustering algorithm, PCA technique	Accurately detects straight as well as curved lanes, Algorithm does not require database for storing images	95%
12.	[12]	2017, IEEE	FPGA system	System is useful to monitor the vehicle to track online the vision detection lane mark and execute obstacle avoidance.	-
13.	[13]	2017, IEEE	Hough transform, morphological operations	Detecting straight as well as curved roads of hilly areas using vision based techniques.	81.67%
14.	[14]	2017, IEEE	Histograms of oriented gradients, SVM Classifier, kalman filter	Accurately detects straight as well as curved lanes	96.3%
15.	[15]	2017, IEEE	Mono- vision based lane detection technique, Sobel filter	Addressed the problem of the generation of an optimal constrained lane reference to be tracked by the automated guided vehicle.	-
16.	[16]	2017, IEEE	Hough- transform, RANSAC Bezier splines fitting, Gaussian filter	Able to find vehicles in front of our vehicle like cars, buses but unable to find two wheelers.	85%
17.	[17]	2017, IEEE	Kalman filter, SVM Classifier	High Accuracy	98.1%
18.	[18]	2017, IEEE	Canny algorithm, Sobel operator, Hough transform	Can detects linear lanes based on Hough transform	-
19.	[19]	2017, IEEE	Feature extraction	Detects lanes in different environment conditions	-
20.	[20]	2017, ICROS	Kalman filter	Accurately detects straight lanes	-
21.	[21]	2017	Randomized Hough Transform	Good accuracy for straight roads	-
22.	[22]	2017	Sobel filter, Hough Transform for Lane Detection	Hough transform was still able to track the loss of lane marks by assuming the lane was still there by counting the number of the lost frame. If the lost track is more than the defined number of frames, then it stopped the Tracking operation.	-
23.	[23]	2017	fuzzy c-means for Segmentation, modifying the Hough transform i.e. hybridization of additive Hough transform with artificial bee colony edge detection to detect curve lanes	In this modify Hough transform i.e. additive Hough transform with artificial bee colony based edge detector is used to get better straight lane as well as curved lane road images	-
24.	[24]	2017	Ellipsoidal Neural Networks with Dendrite Processing (ENNDPs)	We have shown how the proposed methodology can be successfully applied to Automatically detect lanes in urban highways.	-
25.	[25]	2017	Hough Transform	This system will work in both day and night situation	-
26.	[26]	2017	Lane coloration Algorithm (modifying the Hough transform i.e. fuzzy logic)	Fuzzy Logic is used to improve straight lane as well as curved lane road images	-
27.	[27]	2016, IEEE	Phase angle varying range (PAVR) to achieve a better position judging	Analyzes the edge position detection method of segmental wireless power supply for electrical vehicles without position sensors	-
28.	[28]	2016, IEEE	CNNs, Hough transform, Canny operator	System can achieve higher recall and accuracy in real scenes videos	90.7%
29.	[29]	2016, IEEE	Speed-adaptive ratio based algorithm	Can predict the speed-adaptive lateral ratio between left and right lanes	-
30	[30]	2016, IEEE	SVM model	Can detect the normal and abnormal lane changes instances	90%
31.	[31]	2016	RFID, V-I Positioning algorithm	-	-

32.	[32]	2016, IJRITCC Journal	Hough transform, Vanishing point based boundary detection	Good results, both straight and slightly curved road are detected.	-
33.	[33]	2015	Gaussian mixture model, RANSAC method	Detects lanes even in sunny and shadow road	95.7%
34.	[34]	2015, IRJET Journal	Hough transform, Bilateral filter, Canny edge detector	Optimal edge detection	-
35.	[35]	2014, IJCSMC Journal	Review Paper	-	-
36.	[36]	2013, IEEE	RANSAC Model, Kalman filter	Faster processing speed, good performance of the system.	93.2%
37.	[37]	2006, IEEE	Review Paper	-	-
38.	[38]	-	Hough transform, Gaussian filter	Faster processing speed (123 m/sec)	-
39.	[39]	2018, IEEE(AJCT Journal)	Review Paper	-	-
40.	[40]	2019	Hough transform, sobel operator	Better accuracy	96%

III. SYSTEM ARCHITECTURE

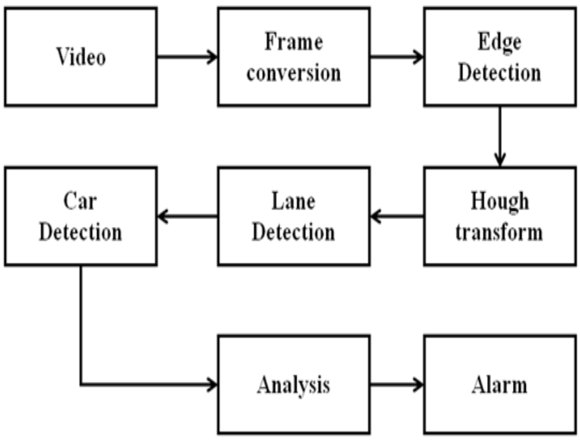

Fig. 2. Proposed Architecture of lane detection system

System is based on following steps:

1) **Video:** Live video is captured using camera fixed in vehicle.
2) **Frame Conversion:** Frames can be obtained from a video and converted into images.
3) **Edge detection:** sudden changes of discontinuities in an image are called as edges. Significant transitions in an image are called as edges. Most of the shape information of an image is enclosed in edges. So first we detect these edges in an image and by using these filters and then by enhancing those areas of image which contains edges, sharpness of the image will increase and image will become clearer.
4) **Hough Transform:** The Hough Transform (HT) is a robust method for finding lines in images that was developed by Paul Hough.
5) **Lane Detection:** Hough Transform is a popular technique to detect any shape, if you can represent that shape in mathematical form. It can detect the shape even if it is broken or distorted a little bit.
6) **Car Detection:** Object Recognition is a computer technology that deals with image processing and computer vision, it detects and identifies objects of various types such as humans, animals, fruits & vegetables, vehicles, buildings etc..Every object in existence has its own unique characteristics which make them unique and different from other objects. RNN (Recurrent Neural Network) is used to detect object (here car).
7) **Analysis:** Hough transform detects lane, change in lane whereas RNN detects vehicle and system analyze and alert if lane changes.
8) **Alarm:** An alarm will alert system when it changes the lane.

IV. IMPLEMENTATION

1. Dataset Collection:

The dataset is of Video Format which is converted into frames for processing which contains videos frames of different videos with different conditions i.e straight road, curved road, night scene etc.

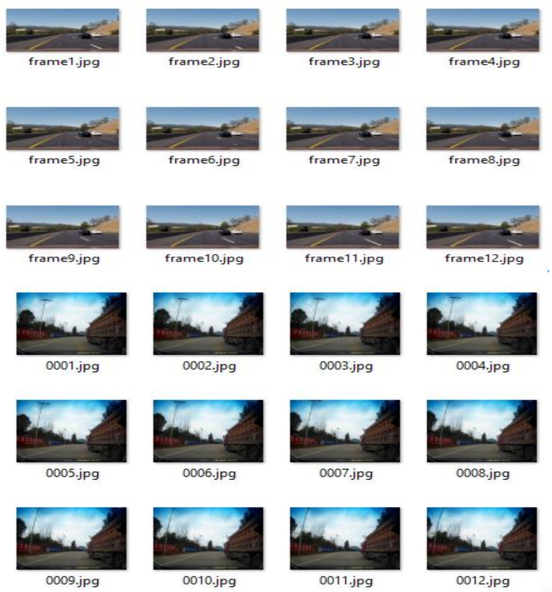

Fig.3. Snapshot of Dataset

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2. EXPERIMENTAL RESULTS:

After applying different algorithms, we have obtained outputs for given system. Canny edge detection and Hough-Transform algorithms have been applied over the dataset.

Step 1: Load image or video

Step 2 : Frame Conversion

The dataset is of Video Format which is converted into frames for processing.

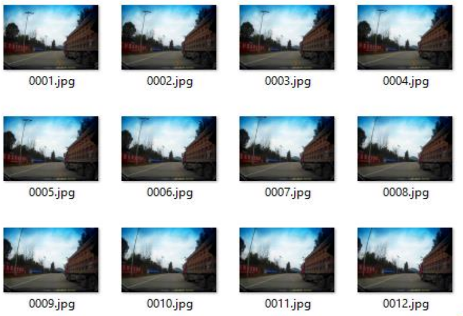

Fig.4. Snapshot of Frames

Step 3: Edge Detection of Image

Algorithm: Canny Edge Detection

Canny edge detection is a method to take out useful structural information from different vision objects and significantly decrease the amount of data to be processed.

Output:

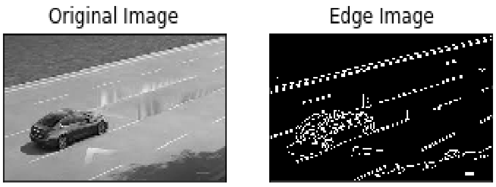

Fig.5: Snapshot of output of edge detection

Step 4: Region of Interest Segmentation

After edge detection by canny edge detection algorithm, we can see that the obtained edge not only includes the required lane line edges, but also includes other unnecessary lanes and the edges of the surrounding fences. This method can increase the speed and accuracy of the system.

Step 5: Lane Detection

Algorithm: Hough-Transform

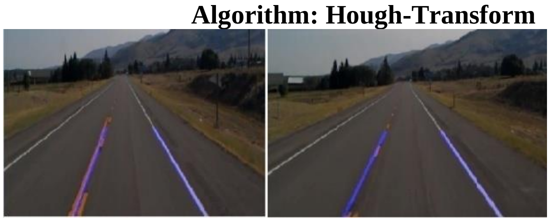

Fig.6: Snapshot of output of lane detection using Hough-transform method

Step 6: Car Detection (Object Detection)

Algorithm: Artificial Neural Network

Fig.7. Snapshot of Car Detection

Step 7: Alarm or Warning

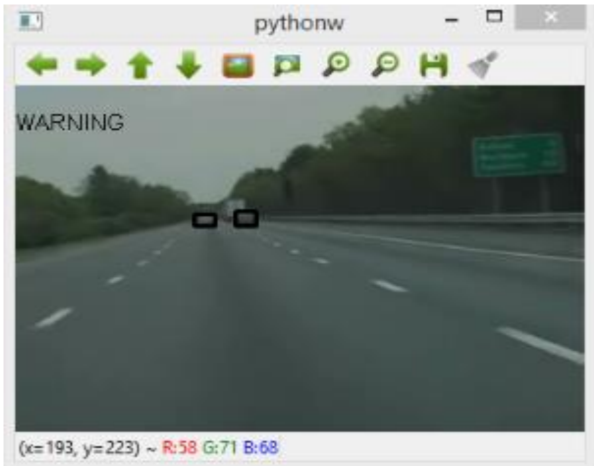

Fig.8. Snapshot of condition when system gives warning after detection of object(car)

V. PERFORMANCE METRICS, RESULTS & ANALYSIS

A. Performance Metrics

As ground truth is not available so we can evaluate the performance metrics of lane detection algorithms by comparing input frames and output frames by calculating true positive(TP), or true negative(TN) or false positive(FP) or false negative(FN).

- TP is when lane region exists in input frame and it is detected successfully by the model proposed.
- FP is when method detects the lane roads even when there is no lane in input frame.
- FN is when there exists a lane region in input frame but method fails to detect.
- TN is when there is no lane region in input frame and algorithm fails to find it.

The metrics used to evaluate performance are the standard methods such as precision, recall, accuracy, F score etc.

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Recall (Sensitivity, TPR, Hit Rate)= TP/TP+FN

Specificity(Selectivity, TNR)= TN / (TN + FP)

Precision(Positive Predictive Value)= TP/TP+FP

Negative Predictive Value(NPV)= TN / (TN + FN)

False Positive Rate(FPR)(Fall-out)= FP / (FP + TN)

False Negative Rate(FNR)(Miss-rate)= FN / (FN + TP)

Accuracy= (TP+TN)/(TP+TN+FP+FN)

F1score= (2 * TP) / ((2 * TP) + (FP + FN))

False Discovery Rate(FDR)= FP / (FP + TP)

False Omission Rate(FOR)= FN / (FN + TN)

Fig 9: Equations to evaluate Performance metrics

B. Results:

Following snapshots shows the results of videos named as VIDEO:1(contains only straight road), VIDEO:2(contains curved road), VIDEO:3(contains mixture of straight plus curved road), VIDEO:4(contains curved road) etc.

```
CLASS: 0

LANE DETECTED:
---------------------------------------------

tp: 4
fp: 5
tn: 119
fn: 0
pos: 4
neg 124
n 128
Recall(Sensitivity,TPR,Hit Rate): 1.0
Specificity(Selectivity,TNR): 0.9596774193548387
Precision(Positive Predictive Value): 0.4444444444444444
Negative Predictive Value(NPV): 1.0
False Positive Rate(FPR)(Fall-out): 0.04032258064516129
False Negative Rate(FNR)(Miss-rate) 0.0
Accuracy: 0.9609375
f1score: 0.6153846153846154
False Discovery Rate(FDR): 0.5555555555555556
False Omission Rate(FOR): 0.0
```

```
CLASS: 1

NOT DETECTED
---------------------------------------------

tp: 119
fp: 0
tn: 4
fn: 5
pos: 124
neg 4
n 128
Recall(Sensitivity,TPR,Hit Rate): 0.9596774193548387
Specificity(Selectivity,TNR): 1.0
Precision(Positive Predictive Value): 1.0
Negative Predictive Value(NPV): 0.4444444444444444
False Positive Rate(FPR)(Fall-out): 0.0
False Negative Rate(FNR)(Miss-rate) 0.04032258064516129
Accuracy: 0.9609375
f1score: 0.9794238683127572
False Discovery Rate(FDR): 0.0
False Omission Rate(FOR): 0.5555555555555556
```

Fig.10. Snapshot of result of VIDEO:1

```
CLASS: 0

LANE DETECTED:
---------------------------------------------

tp: 2
fp: 7
tn: 106
fn: 6
pos: 8
neg 113
n 121
Recall(Sensitivity,TPR,Hit Rate): 0.25
Specificity(Selectivity,TNR): 0.9380530973451328
Precision(Positive Predictive Value): 0.2222222222222222
Negative Predictive Value(NPV): 0.9464285714285714
False Positive Rate(FPR)(Fall-out): 0.061946902654867256
False Negative Rate(FNR)(Miss-rate) 0.75
Accuracy: 0.8925619834710744
f1score: 0.23529411764705882
False Discovery Rate(FDR): 0.7777777777777778
False Omission Rate(FOR): 0.05357142857142857
```

```
CLASS: 1

NOT DETECTED
---------------------------------------------

tp: 106
fp: 6
tn: 2
fn: 7
pos: 113
neg 8
n 121
Recall(Sensitivity,TPR,Hit Rate): 0.9380530973451328
Specificity(Selectivity,TNR): 0.25
Precision(Positive Predictive Value): 0.9464285714285714
Negative Predictive Value(NPV): 0.2222222222222222
False Positive Rate(FPR)(Fall-out): 0.75
False Negative Rate(FNR)(Miss-rate) 0.061946902654867256
Accuracy: 0.8925619834710744
f1score: 0.9422222222222222
False Discovery Rate(FDR): 0.05357142857142857
False Omission Rate(FOR): 0.7777777777777778
```

Fig.11. Snapshot of result of VIDEO:2

```
CLASS: 0

LANE DETECTED:
---------------------------------------------

tp: 1
fp: 5
tn: 93
fn: 5
pos: 6
neg 98
n 104
Recall(Sensitivity,TPR,Hit Rate): 0.16666666666666666
Specificity(Selectivity,TNR): 0.9489795918367347
Precision(Positive Predictive Value): 0.16666666666666666
Negative Predictive Value(NPV): 0.9489795918367347
False Positive Rate(FPR)(Fall-out): 0.05102040816326531
False Negative Rate(FNR)(Miss-rate) 0.8333333333333334
Accuracy: 0.9038461538461539
f1score: 0.16666666666666666
False Discovery Rate(FDR): 0.8333333333333334
False Omission Rate(FOR): 0.05102040816326531
```

```
CLASS: 1

NOT DETECTED
---------------------------------------------

tp: 93
fp: 5
tn: 1
fn: 5
pos: 98
neg 6
n 104
Recall(Sensitivity,TPR,Hit Rate): 0.9489795918367347
Specificity(Selectivity,TNR): 0.16666666666666666
Precision(Positive Predictive Value): 0.9489795918367347
Negative Predictive Value(NPV): 0.16666666666666666
False Positive Rate(FPR)(Fall-out): 0.8333333333333334
False Negative Rate(FNR)(Miss-rate) 0.05102040816326531
Accuracy: 0.9038461538461539
f1score: 0.9489795918367347
False Discovery Rate(FDR): 0.05102040816326531
False Omission Rate(FOR): 0.8333333333333334
```

Fig.12. Snapshot of result of VIDEO:3

```
CLASS: 0

LANE DETECTED:
---------------------------------------------

tp: 1
fp: 5
tn: 68
fn: 4
pos: 5
neg 73
n 78
Recall(Sensitivity,TPR,Hit Rate): 0.2
Specificity(Selectivity,TNR): 0.9315068493150684
Precision(Positive Predictive Value): 0.16666666666666666
Negative Predictive Value(NPV): 0.9444444444444444
False Positive Rate(FPR)(Fall-out): 0.0684931506849315
False Negative Rate(FNR)(Miss-rate) 0.8
Accuracy: 0.8846153846153846
f1score: 0.18181818181818182
False Discovery Rate(FDR): 0.8333333333333334
False Omission Rate(FOR): 0.05555555555555555
```

```
CLASS: 1

NOT DETECTED
---------------------------------------------

tp: 68
fp: 4
tn: 1
fn: 5
pos: 73
neg 5
n 78
Recall(Sensitivity,TPR,Hit Rate): 0.9315068493150684
Specificity(Selectivity,TNR): 0.2
Precision(Positive Predictive Value): 0.9444444444444444
Negative Predictive Value(NPV): 0.16666666666666666
False Positive Rate(FPR)(Fall-out): 0.8
False Negative Rate(FNR)(Miss-rate) 0.0684931506849315
Accuracy: 0.8846153846153846
f1score: 0.9379310344827586
False Discovery Rate(FDR): 0.05555555555555555
False Omission Rate(FOR): 0.8333333333333334
```

Fig.13. Snapshot of result of VIDEO:4

Following table shows that the results of Hough transform operator which is performed on video dataset which contains video frames of straight and curved roads.

Table 2: Performance metrics of Video dataset trained using Hough transform

Sr. No.	Parameters	Class 0 (Lane Detected)	Class 1 (Not Detected)
1.	TP	4	119
2.	FP	5	0
3.	TN	119	4
4.	FN	0	5
5.	Positive	4	124
6.	Negative	124	4
7.	Total (N)	128	128
8.	Accuracy	0.96	0.96
9.	True Positive Rate (Recall)	1.0	0.96
10.	True Negative Rate (Specificity)	0.96	1.0
11.	Positive Predictive Value (Precision)	0.45	1.0
12.	F1 score	0.62	0.98
13.	Negative Predictive Value (NPV)	1.0	0.45
14.	False Positive Rate (Fall-out)	0.04	0.0
15.	False Negative Rate (Miss-rate)	0.0	0.04
16.	False Discovery Rate (FDR)	0.56	0.0
17.	False Omission Rate (FOR)	0.0	0.56

C. Analysis:

According to following results straight road gives the better accuracy than curved roads. The accuracy for

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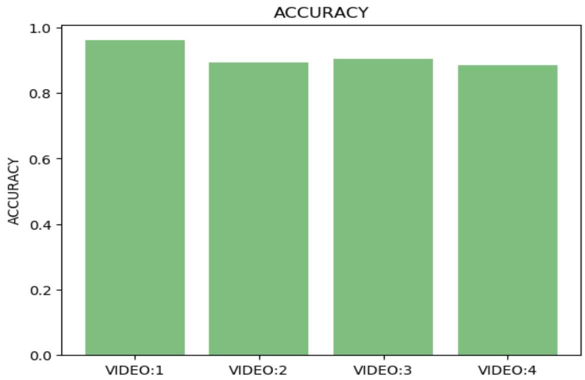
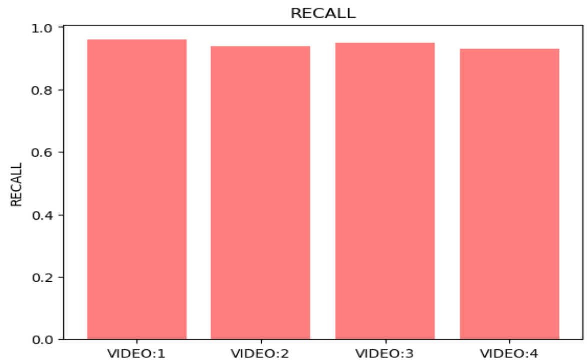
straight road is 96.23% and accuracy for curved road is 90%.

1) Accuracy:



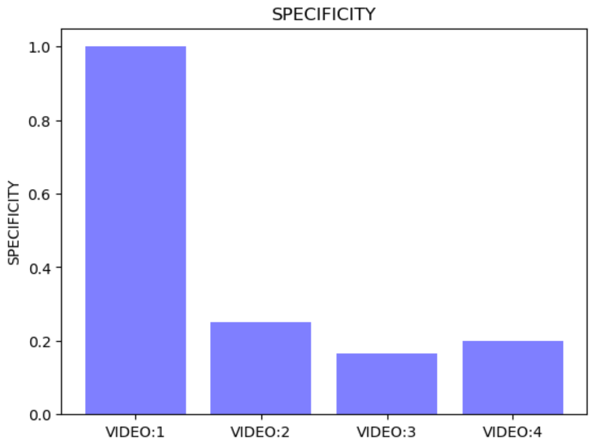
2) Recall:

In information retrieval, recall is the fraction of the relevant documents that are successfully retrieved. It is also called as true positive rate(TPR).



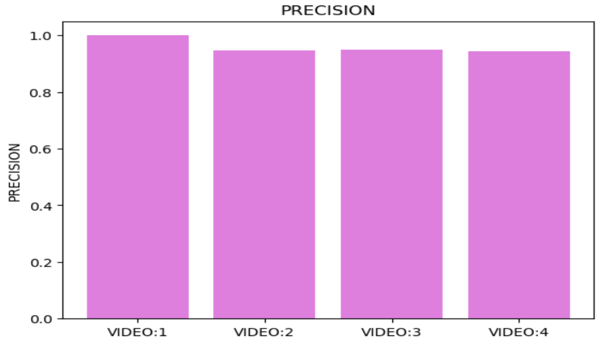
3) Specificity:

Specificity measures the proportion of actual negatives that are correctly identified. It is also called the true negative rate(TNR).



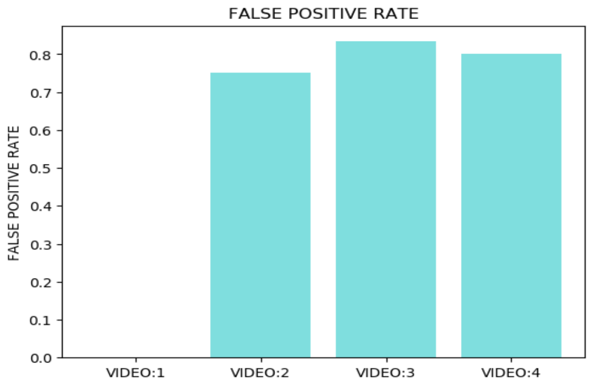
4) Precision:

In the field of information retrieval, precision is the fraction of retrieved documents that are relevant to the query. It is also called as positive predictive value(PPV).



5) False Positive Rate:

The false positive rate is calculated as the ratio between the number of negative events wrongly categorized as positive (false positives) and the total number of actual negative events.



Advantages:

1. Reduced risk when multiple distractions are present such as when loud children are in the car.
2. Safer highway driving.
3. Accident prevention late at night, when fatigue may lead to lane departure.
4. Improved protection for teen drivers, who have a tendency to drift in the lane.
5. More warning of accidents when driving in adverse weather conditions.
6. Compensates for human error when driving.

Applications:

1. Reduce unnecessary information in an image while preserving the structure of image.
2. Extract important features of image like curves, corners, and lines.
3. Recognizes objects, boundaries and segmentation.
4. Plays a major role in computer vision and recognition.

VI. CONCLUSION

Lane departure warning is an inevitable module in the advanced driver assistance systems. In the last decade several advancements occurred in the lane detection and tracking field. Vision based approach is a very simple modality for detecting lanes. Even though lot of progress has been attained in the lane detection and tracking area, there is still scope for enhancement due to the wide range of variability in the lane environments.

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