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Straight and Curve Lane Detection System for Car Safety using Hough Transform and Sobel Operator

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ABSTRACT

Vehicle safety is the most important strategy used to address the international and national road casualty reduction targets to achieve a safer road traffic system. Traffic accidents are mainly caused by human mistakes such as lack of concentration, misbehavior and distraction. The vision based lane detection system is a valuable way to protect single vehicle from accident. In this paper a lane detection method for detecting the lanes accurately is proposed. Also the canny algorithm is determined as the edge detection algorithm and Hough transform method is selected as the efficient way to detect lanes. To meet the real requirement, the region of interest (ROI) is defined to reduce noise properly for accurate results and to enhance the processing speed.

Key words: Canny Algorithm, Edge Detection, Feature Extraction, Hough Transform, Lane Detection, Region of Interest(ROI).

1. INTRODUCTION

According to review of World Health Organization(WHO), in china more than 200,000 people die each year because of road accidents. currently, detecting road lanes accurately is an important concern. Lane boundaries enables vehicles to stay in the proper lane and avoid car crashes.

The typical method for lane detection consists of four main steps: Pre-processing, feature detection, fitting and tracking. In pre-processing step, a system removes noise and prepares images for the further steps. To detect straight lines, Hough transform and related algorithms are used. To detect the lane mark, traffic signs, traffic light, obstacles, we can use camera sensor on an autonomous vehicle.

2.LITERATURE OVERVIEW

New technologies have the capability to increase risk and decrease crash and injury risks simultaneously. The services provided in this project are given below:

- To detect the lanes on road and to inform the driver if he/she is going to change the lane without indicating for his/her intention.
- To indicate driver while changing the lane
- To measure the distance between two cars to avoid car crashes.

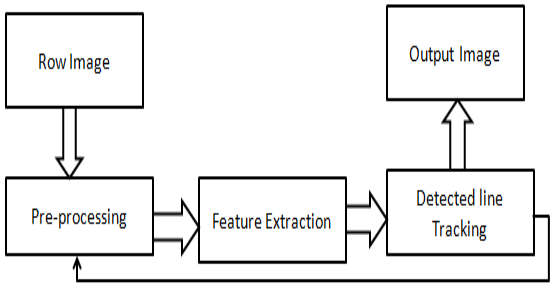

Figure 1: General architecture of lane detection system

The loop shows that the tracked position of the lane markings after detecting the lanes will be used for further processing.

In above figure, once the input image is pre-processed, lane features such as colours and edge features will be extracted. To detect the straight lines, hough-transform method is used[2].

Lane detection method often follows a process with the following steps:

- Capture a image from the camera sensor
- Convert the original image into grayscale image
- Threshold the image
- Find the lane mark by lane line
- Use filter

Using above steps, most of the researchers usually focuses on improving the accuracy of the detected lane mark, increase detection speed and reduce complexity.

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 embeded sensors technology	-
5.	[5]	2017	LDWS Algorithm, Canny's Algorithm, Hough Transform Technique	High accuracy and robustness against noise and model imperfection	-
6.	[6]	2017, IEEE	Canny edge detection algorithm, Hough transform Method	Faster processing speed	-
7.	[7]	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%
8.	[8]	2017, IEEE	Spatio-Temporal incremental clustering algorithm, PCA	Accurately detects straight as well as curved lanes, Algorithm does not require database for storing images	95%
9.	[9]	2017,IEEE	FPGA system	System is useful to monitor the vehicle to track online the vision detection lane mark and execute obstacle avoidance.	-
10.	[10]	2017, IEEE	Hough transform, morphological operations	Detecting straight as well as curved roads of hilly areas using vision based techniques.	81.67%
11.	[11]	2017, IEEE	Histograms of oriented gradients, SVM Classifier, kalman filter	Accurately detects straight as well as curved lanes	96.3%
12.	[12]	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.	-
13.	[13]	2017, IEEE	Hough- transform, RANSAC Bezier splines	Able to find vehicles in front of our vehicle like cars, buses but unable to	85%

			fitting, Gaussian filter	find two wheelers.	
14.	[14]	2017, IEEE	Kalman filter, SVM Classifier	High Accuracy	98.1%
15.	[15]	2017, IEEE	Canny algorithm, Sobel operator, Hough transform	Can detects linear lanes based on Hough transform	-
16.	[16]	2017, IEEE	Feature extraction	Detects lanes in different environment conditions	-
17.	[17]	2017, ICROS	Kalman filter	Accurately detects straight lanes	-
18.	[18]	2017	Randomized Hough Transform	Good accuracy for straight roads	-
19.	[19]	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	-
20.	[20]	2016, IEEE	CNNs, Hough transform, Canny operator	System can achieve higher recall and accuracy in real scenes videos	90.7%
21.	[21]	2016, IEEE	Speed-adaptive ratio based algorithm	Can predict the speed-adaptive lateral ratio between left and right lanes	-
22.	[22]	2016, IEEE	SVM model	Can detect the normal and abnormal lane changes instances	90%
23.	[23]	2016	RFID, V-I Positioning algorithm	-	-
24.	[24]	2015	Gaussian mixture model, RANSAC method	Detects lanes even in sunny and shadow road	95.7%
25.	[25]	-	Hough transform, Gaussian filter	Faster processing speed (123 m/sec)	-

3. SYSTEM ARCHITECTURE

Following proposed architecture shows the whole process of lane detection.

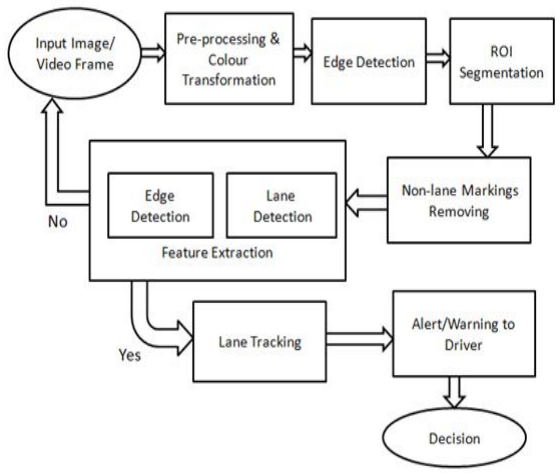

Figure 2: Proposed Architecture of lane detection system

System is based on following steps:

1. Pre-processing

Pre-processing is an important aspect in lane detection to increase the accuracy of system. Pre-processing can help reduce the complications of the algorithm also can reduce the program processing time. In order to improve the accurateness of lane detection, many researchers utilize different image pre-processing technique. The main purpose of filtering is to remove image noise and enhance the effect of the image.

2. Colour Transformation

Colour model transform is an important part of machine vision, and it is also an necessary part of lane detection in this paper. We cannot detect the partition of white lines, yellow lines, and vehicles from the surroundings.

3. Feature Extraction

In order to improve the accuracy of lane detection, we add a feature extraction module in the pre-processing stage. The purpose of feature extraction is to keep any

features that may be lane and remove features that may be non-lane. Feature extraction can be carried out on the colour, background and foreground[2].

4. Edge Detection

This project will be helpful to carry out edge detection in two ways, the first way is to perform a wide range of edge detection extraction in the entire frame image. In the second, the edge detection is performed again after the lane detection after selection of region of interest. This detection further improves the accuracy of lane detection using Canny edge detection algorithm.

5. ROI Selection

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 part.

6. Lane Detection

The methods of lane detection include characteristic based methods and model-based methods. The method based feature is used in this paper to detect the colour and edge features of lanes in order to improve the accuracy and efficiency of lane detection.

To attain straight lane detection Hough line detection function which is encapsulated by the OpenCV library and sobel operator are used.

4. 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.

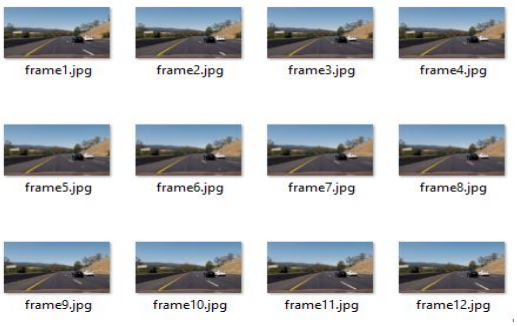

Figure 3: Snapshot of Dataset

2. Experimental Results

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

Step 1: Load image or video

Step 2: 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.

- The Process is separated into 5 different steps:

1. **Noise Reduction**

To remove the noise in the image with Gaussian filter.

2. **Finding Intensity Gradient of the Image**

Smoothened image is then filtered with a Sobel kernel in both horizontal and vertical direction to get first derivative in horizontal direction (G_x) and vertical direction (G_y).

3. **Non-maximum Suppression**

To remove any unwanted pixels which may not comprise the edge.

4. **Hysteresis Thresholding**

This stage decides which edges are really edges and which are not. For this, we need to calculate two threshold values, i.e *minVal* and *maxVal*. Any edges which have intensity gradient more than *maxVal* are considered as a edges and those which have intensity gradient below *minVal* are considered as a non-edges, so discarded.

Output:

Following image shows the detected edges of gray image.

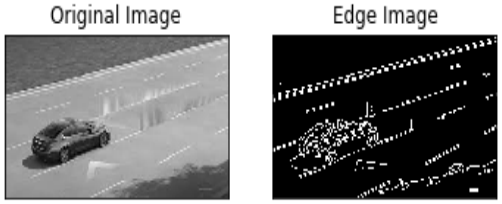

Figure 4: Snapshot of output of edge detection

Step 3: Region of Interest Segmentation

Algorithm: Grab cut Method

After detecting the edges next step is to extract the foreground and background. Grab Cut is an image segmentation method which is based on graph cuts.

Output:

Given image shows that foreground and background are separated successfully.

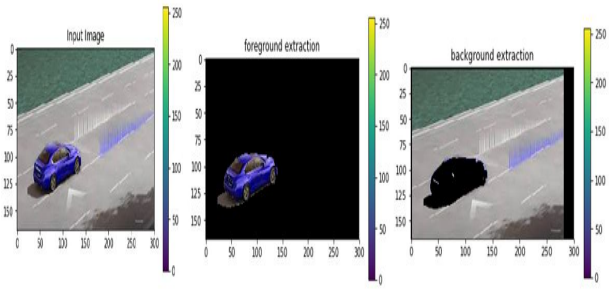

Figure.5: Snapshot of output of ROI segmentation

Step 4: Lane Detection

Algorithm: Hough-Transform

The **Hough transform** is a feature extraction technique used in image analysis, computer vision, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure.

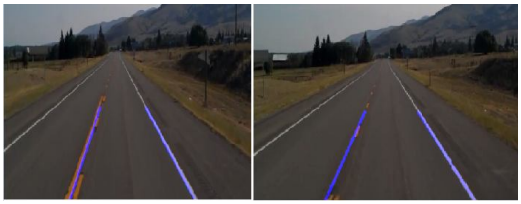

Figure 6: Snapshot of output of lane detection using Hough-transform method

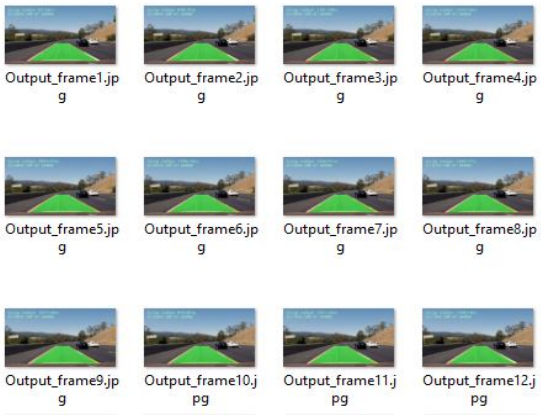

Figure.7: Snapshot of output of lane detection using sobel operator method

5. PERFORMANCE METRICS & RESULTS

We 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 and F score.

$$Precision = TP/TP+FP$$

$$Recall = TP/TP+FN$$

$$Accuracy = TP+TN/TP+TN+FP+FN$$

$$F\ Score = 2*(Precision * Recall/Precision+ Recall)$$

Figure 8: Equations to evaluate Performance metrics

Following table shows that the results of sobel 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 sobel operator

Algorithm	Sobel Operator
Precision	0.9958
Recall	0.9598
Accuracy	0.9637
F Score	0.9773

6. CONCLUSION

In this paper, a lane detection method for lane detection System is proposed. Literature survey tells that the Canny detector is the most efficient method for edge detection. Hough transform is used to detect straight lines. Region of Interest improves the speed of the lane detection significantly and reduces the error rate greatly. At last, experiment results indicate that this lane detection method can extract lane information from road images accurately.

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