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Additive Hough Transform and Fuzzy C-Means Based Lane Detection System

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Abstract

Lane Identification system is contrived to end the deadly road mischances. Numerous analysts are putting endeavors for making lane detection more productive, however regardless it contains many downsides. In this research work performance of Lane detection is enhanced by collaboration of Additive Hough Transform and Fuzzy C Means. Additive Hough Transform is used for shape reorganization and for efficient segmentation process Fuzzy C Means has been used. Outcomes shows that the algorithm works well on the near as well as far part of the image and can easily detects the straight and curved lanes but the problem come when during rainy season or night time.

Keywords*: Intelligent Transport system, Additive Hough Transform (HT), Fuzzy C-Means, Thresholding, Sensitivity, Specificity*

1. Introduction

To enhance the safety on road, automotive industry attempting to create secure vehicle named as Intelligent Transport System or Artificial Driver System. Intelligent Transport System is a system in which computation technology (Information and communication Technology) is collaborated with road transportation. ITS contains numerous modes of transport and consider all essentials of transportation such as automobiles, infrastructure around the vehicle and the driver, which interacts with each other dynamically The utilization of ITS for road system operation make it feasible to attain more information about the road and surroundings through which efficiency and security of road get enhanced. Recognition of lanes is cardinal application of intelligent transport system [18].

Numerous analysts have examined that the majority of the smashes occur when driver takes vehicle out of path, when they doesn't changes their path [2] deliberately or when a few path blends together. So it is important to develop such system that help driver to move with in the lane. Lane is a part of streets that set streets apart to control or guide drivers and diminish traffic issues. That is the reason it is imperative to move inside of the path however once in a while the driver disregard the path purposefully or unexpectedly. Specialists discovered such frameworks that can give directions to the driver to move with in the path. As shown in Figure 1, road is marked with white dashed lanes and vehicles are moving in a specific lane. So it is important to develop a system which can guide or help the driver.

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Figure 1. Road Marked with White Lanes and Vehicles are Moving inside the Lanes

1.1. Lane Detection System

Lane detection is system in which a camera is available at front of vehicle which Capture the pictures of the perspective present in the front of the vehicle that pictures go about as input of the framework. Lane Detection algorithm than find marked lanes on the road and then represent the location of lanes to the driver on external display or caution the driver when vehicle moves out of the path [24]. Recognizable proof of street path from the picture is a testing assignment on the grounds that a picture comprises of commotion. Commotions for example, poor lightning, mist, water on street or numerous different unsettling influences, shadows, overwhelming vehicle covering the street and so forth. So it is imperative to build such calculation or framework that can recognize the paths of the street by overlooking such unsettling influences.

Figure 2. Lanes Detected by System [20]

1.2. Organization of Paper

Further, the paper consists of six areas. In Section 2, examination is done on proposed plane detection systems to discover pros and cons of the strategies utilized. Area 3 gives the detail clarification of the proposed algorithm. In Section 4 different outputs are shown for different input images. In Section 5 distinct metrics have been considered so as to do performance analysis. At the end paper is concluded in section 6 following by future scope that is given in section 7.

2. Related Work

Plenty of vision based techniques have been developed to make ITS more efficient Implementation of Lane identification and tracking system was started in 1990 named as RALPH, GOLD [8]. **Sivagami. M *et al.* (2014)** developed an idea of artificial "co-drivers" as an empowering innovation for smart transportation system. Co-driver created for the EU venture interactive as a case instantiation of this idea, showing how it fits in with the given rules. Specifically, [12] recognizes a scope of utilization fields, indicating how it constitutes a widespread empowering innovation for both brilliant vehicles and agreeable frameworks, and normally sets out a project for future exploration. Hough Transform discovered [16] straight model in close field where as River Flow model displayed to recognize far field edges which could persistently distinguish and track path edges. B-Spline was anticipated with Kalman Filter to find lane continuously. Further advancement on river flow strategy will be explored later on. The idea of river flow strategy could be further stretched out to accomplish naturally visible and minuscule enhanced numerical portability models. Primary system, have been composed and actualized in 1990, [8] for example, RALPH, SCAR, LANA. They surveyed on work that has been done on vision system that goes for continuous path or street understanding under an extensive examination point of view, for proceeding onward to higher request undertakings joined with various path investigation parts, and presents related work along four autonomous. They define and gave statements for comprehension key thoughts in related work; it additionally introduces chose points of interest of conceivably material techniques, and shows applications for delineating progress.

Lane Departure Identifier system has been proposed which just uses three [3] path related parameters in view of the Euclidean separation change to register the path flight of a vehicle. The PLSF is utilized to build the complexity level of the ROI, which enhances the path identification rate. The division of the ROI is completed to distinguish path limits autonomously. This methodology diminishes the computational time required for the path identification. At last, a path take off measure is figured utilizing the Euclidean separation change for every casing construct just with respect to three path related parameters. The proposed approach is beneficial and verified with genuine recordings and pictures under different lighting conditions. Moreover, street sign identification can be additionally consolidated that makes a system more effective. **Yi *et al.* 2015** [2] develop a path recognition and path flight technique. More computation time was needed by the ordinary Hough change inferable from the trigonometric operations and increases. Keeping in mind the end goal to meet on going environment prerequisites the proposed path recognition calculation utilizes a changed Hough Transform joined with an expectation calculation to separate the path. These trials were keeping running under the OpenCV environment. [12] In this paper, they proposed another driver help system in light of picture handling methods. The system gives the capacities of path recognition, vehicle location, and separation estimation for sidelong vehicle. Results demonstrate its power in the instances of complex environment conditions but the system give better results only for straight path. **Kim KB *et al.*** [15] proposed technique using Hough Transform and B-Snake for analyzing shape of roads. Firstly they divide the image into two halves the lower part selected for lane detection. Edges were extracted using 4-directional contour tracking and fuzzy c mean was used for extraction of distance and angle values. Proposed algorithm increased the accuracy but decreases the execution time. In "Image Segmentation by Fuzzy C-Means Clustering Algorithm with a Novel Penalty Term" foreground objects are extracted by fuzzy C- means, bit plane slicing and optical flow. Processing of image is done by lab colour model and bit plane slicing before modelling background image a frame is developed by fuzzy c- mean. At the end, optical flow is applied on image that was received by extracting foreground to banish errors. Proposed algorithm reduces the memory space and execution time.

P.M. Daigavane *et al.* (2010) applied hybrid approach *i.e.* ant colony optimization with canny for edge detection and after that for detecting lanes Hough Transform has been used. The proposed lane detection system works on painted roads and straight roads only [20]. A tracking algorithm based on b-Snake was proposed without camera parameters. The problem of detecting both sides of lane with the middle lane is merged. With the help of CHEVP is used for finding good initial position for B-Snake and then Minimum Mean Square Error find the control points of B-Snake. The technique proposed can be applied on marked, unmarked and dashed road.

3. Proposed Algorithm

Lane detection is critical to lateral vehicle guidance and lane departure warning which can reduce many preventable accidents. Due to diversity of road structures, different weather conditions or miscellaneous activities on road make lane detection more complicated. In the recent years many researches has been done on lane detection system. As we have studied in previous section a large portion of edge based strategies, thusly utilize straight lines to demonstrate lane edges. Other utilized more mind boggling methods such as B-Spline, Parabola and Hyperbola with its capacity to recognize flawed occurrences of standard shapes. These methods work well for straight lanes but problem come when there occurs sharp edges. System uses edge based techniques for path allocation. After edge recognition step, the edge based techniques arrange the identified edges into signified structures. In this paper proposed Additive Hough Transform is used for edge recognition and Fuzzy C Means is applied for segmentation.

3.1. Additive Hough Transform

Hough Transform implemented firstly in 1962 by P.V.C Hough. Hough Transform is the method used to recognition of shapes present in the image. It tells us what kind of feature and how many of them exist in the image.

The technique convert points of the image space to line or a curve in Hough space which is known as mapping function. After conversion, with the help of some of the properties of Hough space detection and identification of some groups of pixels will provide us the information required for drawing these lines. These pixels should have familiar properties like being on a same line or crossing set of lines it is an efficient method to identify unbended lines in pictures, even in existence of noise and missing information. This change can find the primary lines of a picture by making different equations of line that is made of every pixel in the image**.** Hough space is a parametric hybrid space [25,8]. The main concept of Hough transform is to present straight line by the parameters of the line, such as m for slope parameter and b for intercept parameter, considering these parameters; representation of line is done by following equation-

$$Y = mx + b \quad [2] \tag{1}$$

The main thought behind Hough Transform is to present straight line not by slope or intercept but rather by the parameters of the line because value of m (slope) and b (intercept) cannot be calculated for the situation where the line is vertical. By considering these prospective different parameters have been invented, signified as r and θ which is known as polar coordinates. Using these parameters relation can be arranged as

$$r = x\cos(\theta) + y\sin(\theta) \tag{2}$$

r = distance between the line and the origin,

θ = angle of the vector from the origin to the closest point on the line [9, 19].

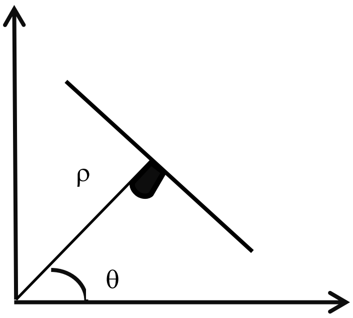

Figure 3. Representation of Line in Parametric Form

Additive Hough Transform is advanced version of HT in additive Hough Transform image is partitioned into small segments and from each segment features are extracted. It uses less memory as compared to Hough Transform and it also computes fast. As shown in figure.

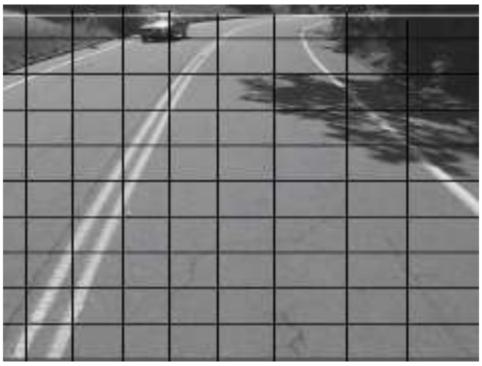

Figure 4. Additive Hough Transform

3.2. Fuzzy C-Mean Segmentation

Image Segmentation is crucial and inceptive step for understanding image or finding any object from it. Basically it is the process of converting colored image to binary image (*i.e*. black and white). There are many methods global and local methods for image binary conversion. Methods of Image Segmentation are based on the intensity value pixels of the image *i.e*. similarity and discontinuity [22]. In proposed algorithm Fuzzy C Means has been used for segmentation process. Fuzzy C mean was invented by Dunn then improved in 1981 by Bezdek [17,14]. Fuzzy C-Means is also known as soft computing. It is a method in which pixels of image are grouped into clusters. A cluster consists of pixels that have something common. Fuzzy C Mean works similar to K-Means segmentation but Fuzzy C-Means allow pixels to be part of one or more cluster. Firstly the clusters are made then centroid of cluster is located by computing the mean of all the pixels which are weighted by their degree of belonging to the cluster. The degree of being in a certain cluster is inverse of the distance to the cluster [16]. Centers of the clusters are updated iteratively and right side of the image.

Following are the steps of Fuzzy C- Mean Algorithm:

Let P = {p_1, p_2, p_3 ..., p_n} be the pixels of the images and V = {c_1, c_2, c_3 ..., c_m} set of centers.

1. Randomly select ‘t’ centers of cluster.
2. Calculate the member ship function m_{ij} by applying formula

$$m_{ij} = \frac{1}{\sum_{n=1}^{t}\left(\frac{\|x_i - y_j\|}{\|x_i - y_n\|}\right)^{2/m-1}} \quad [12]\ (3)$$

3. Calculate center u_j by applying following formula

$$u_j = \left(\sum_{i=1}^{n}\left(\mu_{ij}\right)^m x_i\right) / \left(\sum_{i=1}^{n}\left(\mu_{ij}\right)^m\right) \qquad \forall_j = 1,2,3 \ldots\ldots t \quad (4)$$

4. Repeat the step 2 and 3 until specified number of iteration are achieved.

3.3. Proposed Algorithm

Algorithm is proposed for the efficient detection of straight as well as curved lanes. Segmentation process is done by Fuzzy C Means which can handle the ambiguity of pixels easily hence enhance the accuracy of proposed algorithm. Hough Transform is mostly used for detecting lanes but problem comes when curved lanes come so image is partitioned into small parts through which curved lanes are easily detected. Following flow chart shows the steps, to be followed to achieve the lane detection system.

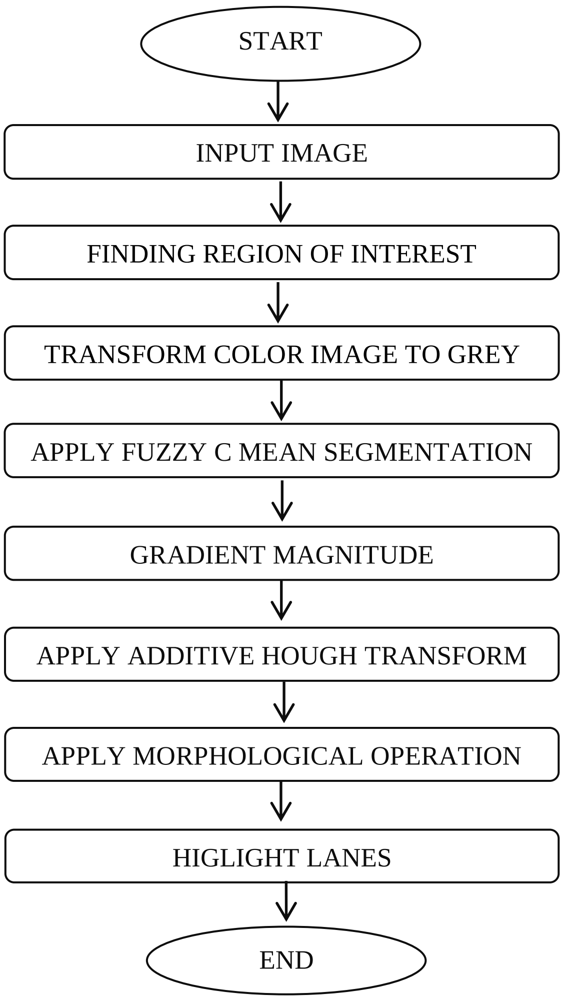

Figure 5. Flow Diagram for Lane Detection System

These steps will take after each other in successive way to identify and highlights the lanes:

Input Image: Initially image of road is taken by camera and passed to proposed algorithm; from that image lanes are highlighted and then displayed on the screen.

Figure 6. Input Image

Calculate Region of Interest: Region of interest is selected form the captured image, so that undesired part of the image is removed and operation is performed on specific part of the image, which diminishes the computational time of the algorithm. To extricate ROI co-ordinates are chosen and as indicated by those co-ordinates, images get edited. Output of ROI is shown in figure 6.

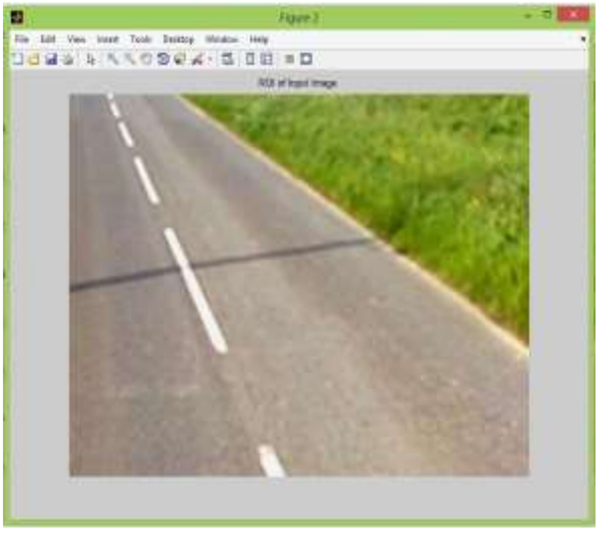

Figure 7. ROI of Image

Transform Color Image to Grey Scale: Coloured image is converted to grey scale as it decreases the processing time. Following figure shows the grey scale image of input image.

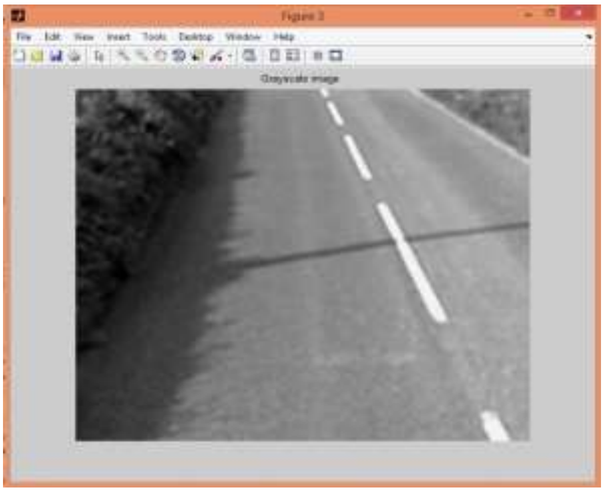

Figure 8. Grey Scale Image

Fuzzy C Means Segmentation: Image is binarized by using fuzzy C Means segmentation which separates the lanes and background region. After applying Fuzzy C Means segmentation background points are put into one class and lane points into other [25]. Figure 8 shows the results of segmented image.

Gradient Magnitude: Here gradient magnitude used to highlight the boundary of the object. Finding image gradient is beneficial because it reduce the chances of error. It also highlights the boundary of the lanes from segmented image.

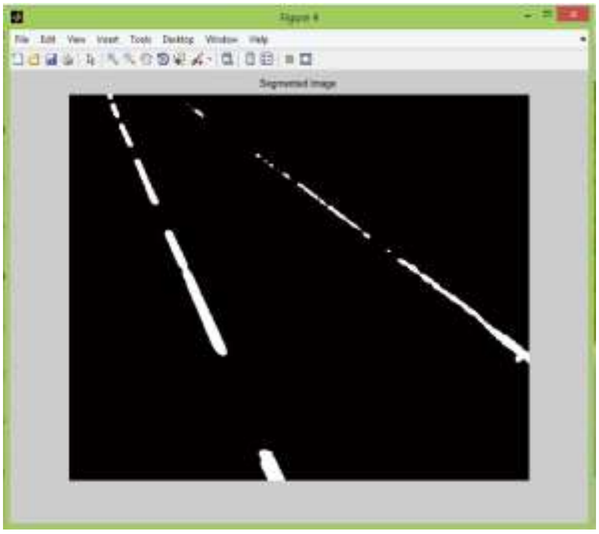

Figure 9. Segmented Image

Additive Hough Transform: To isolate features of particular shape Hough Transform is used**.** Simple Hough Transform not able to detect lanes at sharp curves so Additive Hough Transform is applied. After applying segmentation foreground is abstracted from background now by applying Additive Hough objects are isolated. Results of Additive Hough Transform is shown in Figure 10.

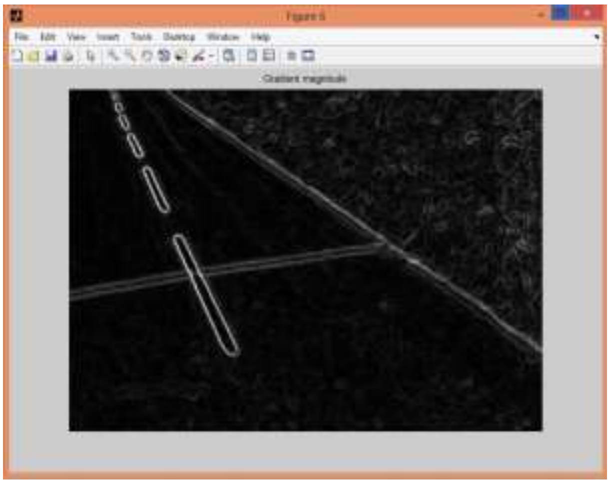

Figure 10. Ouput of Gradient Magnitude

Morphological Operation: Binary Image produced by segmentation process consists of noise so to overcome this morphological process is applied.

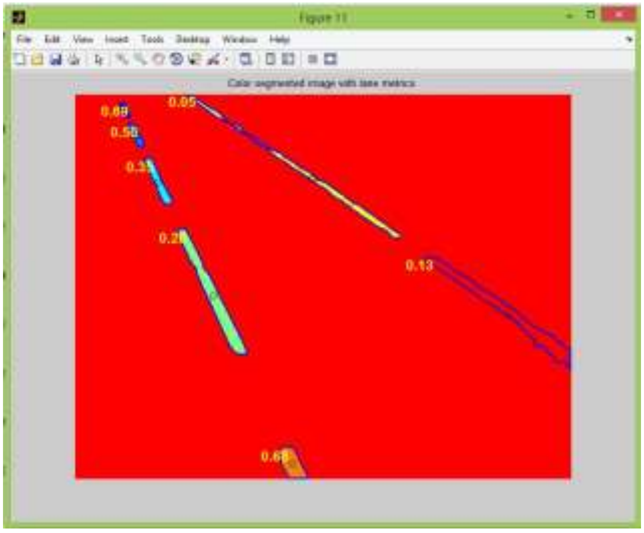

Figure 11. Results of Hough Transform

Detect Lanes & Colour: When process of lane detection is completed the detected lanes are highlighted with the different colour. As shown in Figure 6 the detected lanes are marked with green color.

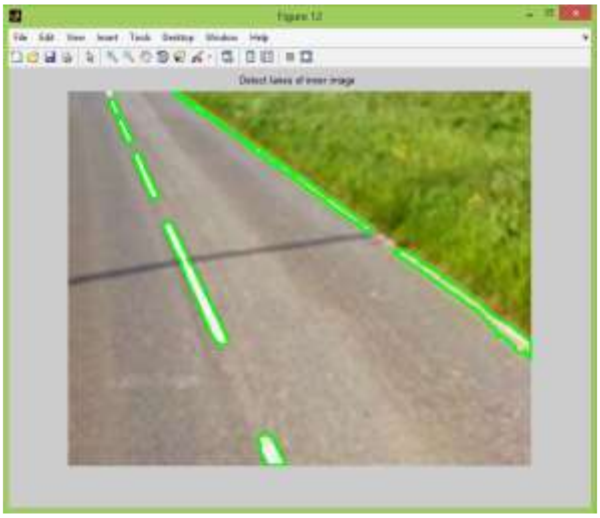

Figure 12. Lanes Highlight

3.4. Functional Process Pseudo Code for Lane Detection System

1. Road lane image.
2. Apply automatic ROI equation
[A,B]=find(imgData~=255);
imgSelect = imcrop(imgData,[xmin,ymin,xmax,ymax]);
imgSelectrgb = imcrop(Image,[xmin,ymin,xmax,ymax]);

3. Convert image to gray scale Image
Img = rgb2gray(image)

4. Convert Grayscale Image to segmented Image
Seg = Gray *1.2;
S = Seg>255;
Seg is scaled value 225 is threshold value

5. Apply fuzzy c mean segmentation

$$\arg\min \sum_{i=1}^{n} \sum_{j=1}^{c} w_{ij}^{m} \|x_i - c_j\|^2$$

Where, $w_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|} \right)^{2/m-1}}$

6. Evaluate gradient magnitude of image
Grad = Sqrt((Image$_x$ axis)^2 + (Image$_y$ axis)^2)

7. Hough Transform is used to recognize the lanes after identification of all the object
Input: Grad;

a. To get(x,y) boundary co-ordinates corresponding to label
Boundary = B(K)

b. To calculate the simple estimate of the objects perimeter
Delta_sq = diff boundary.^2;
Parimeter = sum(squrt(sum(delta_sq,2)));

c. To get the area calculation corresponding to label K

Area = stats(K). Area;
d. To compute the roundness metric
$M = \frac{4\pi r}{p^2}$
e. For decision
If metric(k) < 0.82 metric > 0.009
Go to step 7
Else no lane found
f. Determine end points of longest line segments
Len = norm(line(k). point1 – lines(k). point2)
Metric = $\begin{cases} 1, if\ c_1 < X < c_2 \\ 0, otherwise \end{cases}$
8. To smooth the lanes
Smooth = bwareaopen(Grad,200);

9. Apply morphological operation
Op = $\begin{cases} 255 \quad if\ pixel\ count \geq t \\ 0 \quad if\ pixel\ count\ \geq t \end{cases}$
Here t is any threshold
10.Highlight the lanes.

4. Experimental Result

Steps shown in Figure 5 are implemented in Matlab. Colored image is read first then region of interest is calculated which is then converted to the grey scale image. Applying Fuzzy C-Mean background is subtracted and applying Hough transform lanes are detected. Below are the figures shown for different situation like straight lane, curved lanes, noisy image *etc*.

a. Image having Straight lanes

Figure shows the input image and output generated from the proposed technique.

Figure 13. Input Image

Figure 14. Detected Lanes

b. Image Contains Noise

Figure shows the input image and output generated from the proposed technique.

Figure 15. Input Image

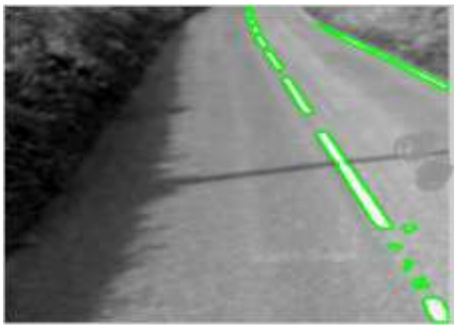

Figure 16. Lanes Detected

c. Image with Curved Lanes

Figure shown below consist of image having sharp curves.

Figure 17. Input Image

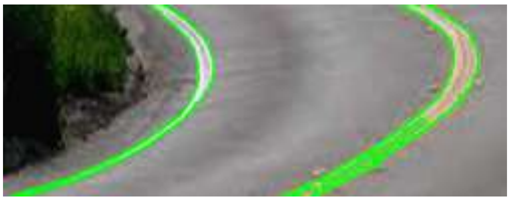

Figure 18. Marked Lanes

5. Performance Evaluation

The path identification is process which should be accurate. There are a lot of variables which influences the path identification. To do execution analysis, diverse measurements have been considered in this paper *i.e*. Geometric Accuracy, F-Measure, Bit Error Rate, Overhead and Execution Time. The execution of path discovery calculations is regularly assessed as far as precision and speed. Comparison is done between the proposed algorithm and present lane detection algorithm.

a. Geometric Accuracy (G Accuracy): Geometric accuracy is precision of a resulted picture contrasted with previous picture. It is calculated as square root of product of sensitivity and specificity.

$$\text{GeometricAccuracy} = \sqrt{\text{sensitivity} \times \text{specificity}}$$

$$\text{Precision} = \frac{total_p}{total_{fp}+total_p}$$

$$\text{Recall} = \frac{total_p}{total_{fn}+total_p}$$

Table 1. GAccuracy

Sr.No	Images	Existing	Proposed
1	1.jpg	0.591	0.9285
2	2.jpg	0.984	0.9908
3	3.jpg	0.997	0.998
4	4.jpg	0.8782	0.9661
5	5.jpg	0.8453	0.9858
6	6.jpg	0.6004	0.9569
7	7.jpg	0.9387	0.9882
8	8.jpg	0.9399	0.9873
9	9.jpg	0.5971	0.9923
10	10.jpg	0.7169	0.9854

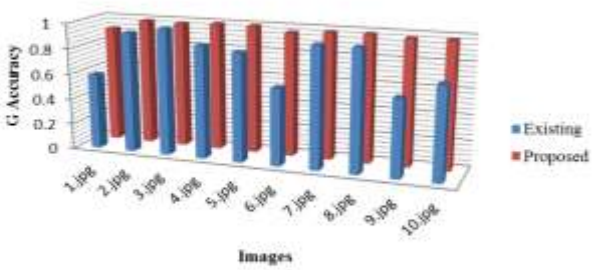

Figure 19. Graph for Geometric Accuracy

b. F-Measure: The F-Measure evaluates the average of the information retrieval precision and recall metrics. Precision is fraction of retrieved instances, it is also known as positive predictive value and recall is the fraction of relevant instances which is obtained. Hence precision & recall are based on measure of relevance. More the F-Measure higher will be the classification/ clustering quality [1]. F-measure can be computed as:

$$\text{F-Measure} = \frac{2\times(precision \times recall)}{precision+recall}$$

$$\text{Precision} = \frac{total_p}{total_{fp}+total_p}$$

$$\text{Recall} = \frac{total_p}{total_{fn}+total_p}$$

Table 2. F-Measure

Sr.No	Images	Existing	Proposed
1	1.jpg	51.768	92.5964
2	2.jpg	98.3891	99.0749
3	3.jpg	99.6948	99.7986
4	4.jpg	87.0853	96.5487
5	5.jpg	83.3526	98.569
6	6.jpg	52.9967	95.6003
7	7.jpg	93.6793	98.8121
8	8.jpg	93.8108	98.7188
9	9.jpg	52.5656	99.2229
10	10.jpg	67.8895	98.5335

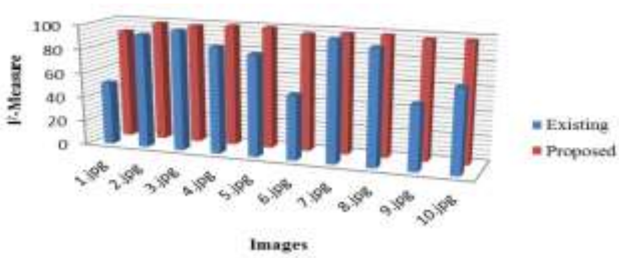

Figure 20. Graph Showing Results of F- Measure

c. Execution Time: Execution time helps to determine the algorithm executed faster. The algorithm with lesser execution time will be considered as better one

Table 3. Execution Time

Sr.No	Images	Existing	Proposed
1	1.jpg	11.0278	7.3619
2	2.jpg	17.553	15.2567
3	3.jpg	18.7634	19.2601
4	4.jpg	9.2341	5.0231
5	5.jpg	14.3747	7.7679
6	6.jpg	7.8387	4.4168
7	7.jpg	7.4052	4.8767
8	8.jpg	11.5831	5.2961
9	9.jpg	13.9659	4.0648
10	10.jpg	6.2637	3.7625

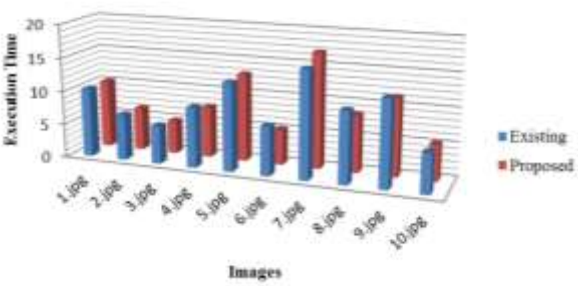

Figure 21. Graph for Execution Time

d. Overheads: It is the extra time (communication time) taken by algorithm to produce the output. Extra time such as time required to read the image, segment image *etc*.

Table 4. Overheads

Sr.No	Images	Existing	Proposed
1	1.jpg	9.4639	2.9019
2	2.jpg	15.36	4.9549
3	3.jpg	16.3937	5.5455
4	4.jpg	7.7329	2.4016
5	5.jpg	12.6376	3.1558
6	6.jpg	6.3071	2.0637
7	7.jpg	5.9905	2.3431
8	8.jpg	10.0014	2.7786
9	9.jpg	12.461	1.8992
10	10.jpg	4.9934	1.8266

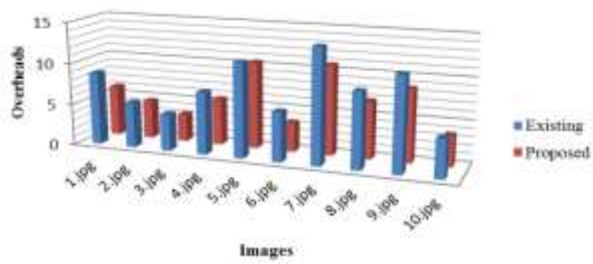

Figure 22. Graph for Overhead

e. Bit Error Rate: Error rate help in determining the error our output contain or how much improvement the algorithm further required. It is the percentage of bits that have errors relative to the total number of bits received in a transmission. It is calculated by formula.

$$\text{Error Rate} = 100 * (1 - \text{balanced classification rate})$$
$$\text{BalancedClassificationRate} = 0.5 \times (\text{sensitivity} + \text{specificity})$$

Table 5. Bit Error Rate

Sr.No	Images	Existing	Proposed
1	1.jpg	0.409	0.0715
2	2.jpg	0.016	0.0092
3	3.jpg	0.003	0.002
4	4.jpg	0.1218	0.0339
5	5.jpg	0.1547	0.0142
6	6.jpg	0.3996	0.0431
7	7.jpg	0.0613	0.0118
8	8.jpg	0.0601	0.0127
9	9.jpg	0.4029	0.0077
10	10.jpg	0.2831	0.0146

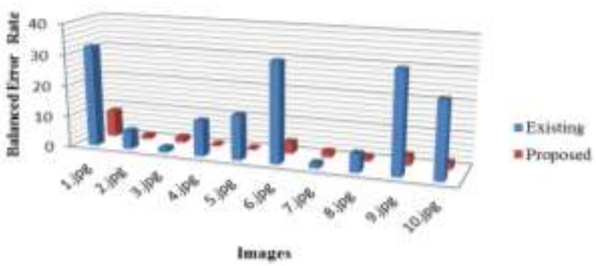

Figure 23. Graph for Bit Error Rate

6. Conclusion

To handle traffic and reduce the road accidents Intelligent Transport System are being developed. Robust lane detection is a crucial application of Intelligent Transport System. Many researchers created different algorithm to make lane detection system more efficient. The developed algorithm give good results for straight lane but fails when it comes to curved lanes. Result obtained shows that proposed algorithm gives efficient results. Initially ROI of the captured image is evaluated which reduces the computation time, and then colored image is converted into the Grey scale image. For segmentation of the image Fuzzy C- Mean is applied which gives good results for all kind of images. After extracting the foreground objects Additive Hough Transform is used which finds the lane from the extracted objects. Morphological Operation helps in elimination of the noise. From above perspectives, it is conclude that the proposed approach is fruitful.

7. Future Scope

In future the existing work can be improved by evaluating the vehicle's co-ordinates with respect to both the lanes, in real world. In the meantime, a fitting driver technique could be coordinated with the proposed algorithm to empower automatic driving system. The proposed system does not give good result in rainy and foggy weather, so enhancement can be done in that part. Moreover, street sign identification can be detected to may system more intelligent. This would encourage dynamic security.

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