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Performance Evaluation of Modified Hough Transform for Road Lane Colorization

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***Abstract**:-Lane colorization is becoming well-liked in present time vehicular ad-hoc network. This study work focus on provide improved performance in lane coloration algorithm by using CLAHE to improve the input image and also by modifying the Hough transform using the dynamic thresholding to identify curve lanes. Major emphasis is to recover the effect of lane coloration algorithm when smog, clatter or any additional issue is present in the images. The methods developed so far are functioning efficiently and give superior results in case when the straight lane path images are there. But difficulty is that they not succeed or not provide efficient results when there are curved lane road images. The experiments outcomes for the road images have shown the major progress of the proposed technique over the existing one.*

Key Terms: LANE, ROAD, ACCIDIENTS, HOUGH, CLAHE.

I. INTRODUCTION

Lane detection is a main, necessary and significant part of intelligent vehicle applications, such as intelligent travel control, lane departure warning, crash prevention, autonomous driving etc. It plays a significant function in vision based intelligent vehicle system. Lane detection is the element of the Driver assistance system. It used to find the location and direction of the vehicle with path information. This information can be used for find other vehicle or blockage in the path for progress of the barrier avoiding system. The aim of Lane recognition is to support the drivers in perceiving any dangerous situation before to stay away from the disaster throughout sensing and identify the road conditions [5] [6] [17] [20].

Driving assistant systems are developed for increasing driving security in recent years. In these systems, machine visualization plays a significant task in lane departure recognition and lane tracking. Vision-based lane detection plays an important role in Advanced Driver Assistance System in order to give significant and reliable road shape information for vehicle routing. The lane detection is used in computer visualization which becomes a powerful tool for sensing the atmosphere. A color camera is mounted in the vehicle at the front-view mirror. It captures the images of the atmosphere in front of the vehicle, including the path, also vehicles on the path. The on-board computer with image capturing card captures the images in real time and keeps them in the computer memory. The lane recognition system read the image series from the memory and initiates the processing [10] [18] [27].

Various lane departures collide especially on high-way roads are due to driver's negligence. Therefore a system is required to save the significant number of lives by warning the driver of coming up danger. In road scene, the lane markings is most important evaluate with other objects, and obviously it attracts more concentration from the drivers. The approaches of lane detection can be classified as: either feature-based or model based. Feature-based method detects lanes by using low-level features like lane-mark boundaries. The feature based method has high dependency on clear lane-marks, and suffer from weak lane-marks, noise and occlusions. Model-based method signifies the lanes as a kind of curve model which can be determined by a few important geometric parameters [3] [15].

Lane departure warning system is a valuable system to avoid those disasters, in which, the lane detection is a key problem. The lane departure warning system is a fundamental part within the driver assistance system, aims to provide warning messages under irregular driving behaviors due to interruption, or driver inattention. The Lane Departure Warning System is a component of the Vehicle security. The Advanced Driver Assistance System based on on-board camera provide current vehicles on the road. Road recognition is the difficulty of find lane boundaries under a variety of lighting situations. Road situation analysis in Interactive Intelligent Driver- Assistance and Safety Warning systems absorbs evaluation and calculation of the location and size of various on-road barriers [16] [23] [24] [25].

In the application of forward collision avoidance, path boundaries and lane boundaries help to differentiate possible collision threats in terms of their application to the planned path of the vehicle. Automatic lane recognition can provide support to human driver's .The information of the lane margins relative to the vehicle allow a driver support system to aware a driver as to whether the vehicle is potentially steering off track. It enhances the security for motorists who do not have the track in order to pass vehicles and provide space in teeming region for motor vehicles to reduce the disaster [14] [18].

The Lane colorization is used for color the lanes to enhance the human visibility. Lane coloration and Lane detection are two dissimilar steps in vision based methods. Lane coloration is the difficulty of discovering lane borders without any prior information of the road, and does so in conditions where there may be limitless clutter in the road image. This clutter can be because of the noise, dust, darkness, oil stains, tire slip marks etc. Lane detection deal with the tracking of the lane boundaries from frame to frame given a presented model of road geometry. After recognition of the lane boundaries perform the colorization of the lanes to improve the human visualization [4].

The lane coloration methodology can be classified into infrastructure-based and vision-based techniques. While the infrastructure-based techniques achieve robustness; build price to put coaxial cables or to locate magnetic indicators on the road surface is high. Vision based techniques with camera on a vehicle have benefits to use well-known existing lane recognition in the road position and to sense a road curves in front view. So Computer vision based approach become particularly significant in traffic applications generally due to their quick response, simple installation, operation and maintenance. Based on the fast improvement of the computer technology mostly peoples depends on the advanced technology to discover the solution of traffic crisis, or no. of countries in the world are used the intelligent transportation system [4] [26].

Intelligent Transportation Systems is a dynamic protection system to avoid unplanned path departure that can lead path intersection and overturn collision. The core task of computer visualization is to complete the recognition and tracking road. Lane Departure Warning System is planned to reduce mishaps through addressing the core causes of accidents: driver mistake, disturbance and sleepiness. It uses a forward looking monocular camera to obtain lanes information for verifying the location of the vehicle relative to the lanes. If a lane departure is happen and the vehicle's turn signal is not in use, than this system provides the driver warning, when a vehicle is running over a certain speed threshold [1] [2] [15].

On the road; there are various insecure driving cars that the driver requires more careful while driving. Essential for the driver is being careful when he/she must change path. Presently, the increasing volume of the traffic all around the earth requires higher levels of the traffic protection. With the rapid development of urban traffic, the traffic security becomes more essential. According to the many accidents of road departure, crashes are cause by driver careless. The investigations in intelligent transportation system imagine that vehicle will be capable to communicate to other vehicle. The central server will hold the velocity and position of the vehicle and combined this data for intelligent transportation system functions, such as determine the path from a vehicle’s current position to its target or identify the place of an incident [8] [16] [13].

With the improvement of urbanization the traffic atmosphere is becoming worse. Traffic blockage is more and more serious and traffic accidents occur repeatedly. Then, the concept of intelligent vehicle navigation is put onward for detect lane. Vehicular ad-hoc Network communication is also most important in the region of wireless networking as well as in the automotive industry. The objective of vehicular ad-hoc network is to expand a vehicular communication system to allow rapidly sharing of data for the help of traveler’s protection. In vehicular ad-hoc network, every vehicle is outfitted through the technology that allows the drivers to talk with each other and also with roadside units, situated in some significant part of the track, in order to develop the driving knowledge and make driving secure. With On-Board Units, vehicle can communicate with each other and also with road side unit. Vanet is a self-controlled system that connects the vehicles and road side units, and the road sides units can be connect to a backbone network [2] [6] [7].

Lane detection in an urban street is a hard problem. Challenges include: poor quality lines, darkness transmit from trees, sharper curves, irregular lane shape, sun glare, writing and extra marking on the road, and different slope. In other areas it also deals with a variety of lane markings, composite atmosphere and road lighting situations. Lane marking feature extraction is a main part for lane recognition. Robust extraction of lane edges in composite road sight is still a difficult problem. Effectiveness of edge extraction of lane markings is critical in various Advanced Driver Assistant System applications, such as lane departure warning, lane change support etc [12] [17] [19].

In lane detection generally the images taken by digital cameras are dissimilar from the original true color image in terms of color and intensity of the picture captured. Therefore, enhancement methods are essential for color images. The Contrast Limited Adaptive Histogram Equalization method provide a way to improving the object detection and identification under low lighting conditions. It is very valuable where the brightness requirement is high. This method partitions the image into appropriate regions and applies the histogram equalization to each one. The histogram equalization significantly changes the brightness of an input image. The resultant equalized image contains a homogeneous distribution of the gray levels and makes hidden features of the image more visible [28].

In general, lane marks are lines and curves like structure. Lane marking can be estimated as straight lines in image. Hough Transformation is one of the most general line recognition method. Within the last few years, various techniques of processing and analyzing images for lane detection have been proposed. Different types of techniques involving slope magnitudes, Gabor filters, Hough transform etc are used to extract lane features. A lot of work has been carried out on vision-based lane detection algorithm. Several of the algorithms select lane with unique colors by the characteristics that consist clear color quality. Roads can be marked by well defined hard lines, fragment lines, rounded reflectors, and physical obstacles [9] [11] [19] [22].

Lanes can be treating as the straight line. Hough Transform is used to identify the straight lines. It attains a type of mapping from the image space to parameter space. It uses duality between point and line to transform the arc specified by the original image space into a point of the parameter space throughout the arc appearance. So, the difficulty of finding specified arc in the original image is transform into the difficulty of discover the peak in the parameter space. In other word, that is convert discovered characteristics into identify the local characteristics, such as circle, curve and so on [18] [1].

Lane detection using Image processing based on edge detection and Hough Transform is worked by setting the webcam camera to monitor the movement of vehicle throughout the lanes, generate a video file to examine input video stream. For lane recognition, initially create a Region of interest (ROI) to eliminate the noise from the feature map. In the road images, a lot of unnecessary information is available which is not useful for lane detection. For useful information select the region of interest. It consist that area in which road surface is included. By select the region of interest, the lane detection algorithm can decrease the running time. Then convert the color image into gray scale image in order to decrease the size of pixel data if the input images include color information because any color information is not essential. The cause for differentiating such images from any other type of color image is that a lesser amount of information needs to be provided for each pixel [10] [11] [13] [21].

A Hough transform and Boundary detection, essential techniques for image processing, are used for detect lane marks that can decrease the loss of visions to the front road in real time. Its advantages are good localization with minimal space between the identified and real boundary location, remove several segments and instead make a single longer boundary. The quality of lane extraction significantly depends on the results of the edge detection. It is used in the field of image detection and image analysis; include classification of objects area and pick-up of area shape [11] [19].

Hough Transform is only applicable on binary images, so edge detection is to be performed to attain a binary image. The boundaries of the lane are sharp and continuous in various situations. Canny edge detector is good at weak boundary recognition. It identify the boundary pixels with the criteria of good recognition, good localization. It smoothes the picture to remove the noise. The detected boundaries pixels are then follow by the Hough transform. The Hough Transform used to recognize the instantly lines. The output Hough Transform is a set of straight lines, some of which can be the lane mark lines. By controlling the angle and length of lines and smallest distance between segments on the same straight line, the perfect lane is extract effectively [1] [19] [11] [23].

II. PROPOSED ALGORITHM

2.1 How Modified Hough based Lane colorization workings

Proposed algorithm takes following steps exposed in Fig. 2.1.

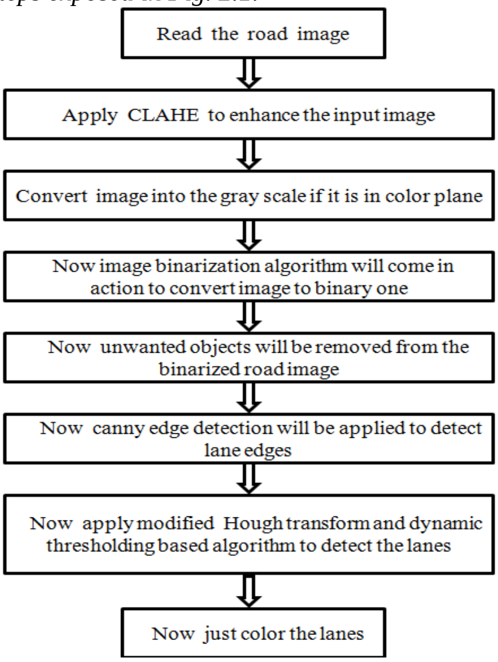


Fig.-2.1 Proposed Algorithm

Step 1: Read the Road image. Read the Road image. In the road images, a lot of unnecessary information is available which is not useful for lane detection. For useful information select the region of interest. It consist that area in which road surface is included. By select the region of interest (ROI), the lane detection algorithm can reduce the running time.

Step 2: Apply Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance the input image. It increase contrast locally and regularly across the whole image. It is very valuable where the brightness requirement is high. CLAHE improves the object detection and identification under low lighting conditions and improves the range of vision systems.

Step 3: Convert image into the gray scale if it is in color plane because any color information is not essential. The cause is that lesser amount of information needs to be provided for each pixel. It is common to change different formats image into gray images, in order to decrease the calculation of the next image processing.

Step 4: Now image binarization algorithm will come in action to convert image to binary one. It simplifies change the representation of an image into something that is more significant and easier to evaluate.

Step 5: Now unwanted objects will be removed from the binarized road image for smooth the image.

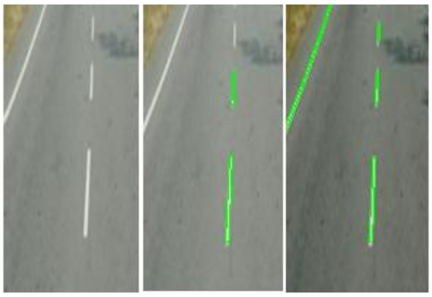
Step 6: Now canny edge detection will be applied to detect lane edges. It finds edges by looking local maxima of the gradient of input image. It uses two thresholds to detect strong and weak edges. If a pixel's magnitude in the gradient image exceed the higher threshold then the pixels correspond to a strong edge and pixel's having magnitude greater than the low threshold correspond to weak edges.

Step 7: Now apply modified Hough transform, and dynamic thresholding based algorithm to detect the lane. The dynamic thresholding performed the area based checking. Hough transform connect pixels which lie on a same line. The simple Hough transform only detects the straight lanes. But modified Hough transform also detects the curved lanes.

Step 8: Now just color the lanes for improve human visualization.

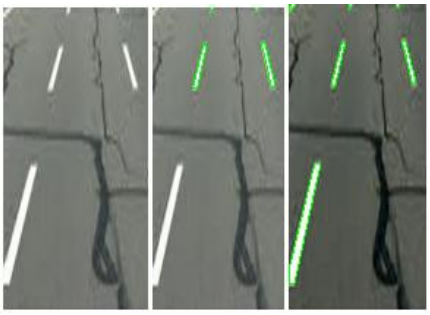
III. EXPERIMENTAL RESULTS

These are some following images which helps to compare the results. The comparative analysis has shown the significant improvement of the proposed technique over the available one.



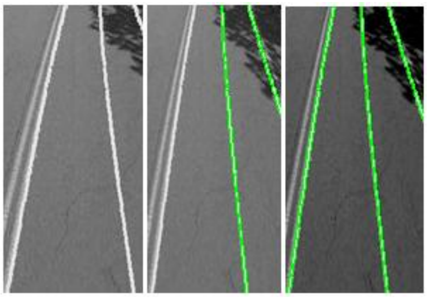
(a) (b) (c)

Fig-1 (a) Input image (b) Result of existing approach without using CLAHE technique (c) Result using CLAHE method



(a) (b) (c)

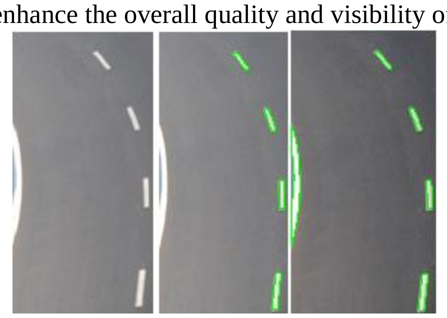
Fig-2 (a) Input image (b) Result of existing approach without using CLAHE technique (c) Result using CLAHE method



(a) (b) (c)

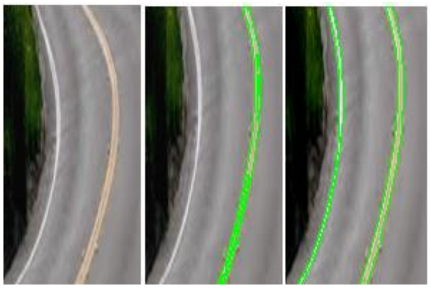
Fig-3 a) Input Image (b) Result of existing approach without using CLAHE technique (c) Result using CLAHE method

The above figures show better human visibility of Input image by using CLAHE technique as compared to previous technique. This method can efficiently enhance the overall quality and visibility of image.



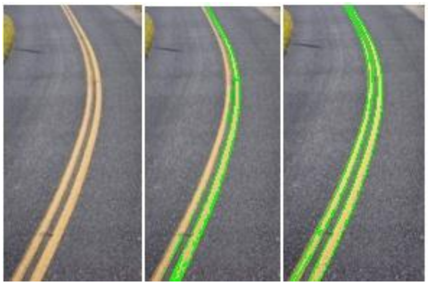
(a) (b) (c)

Fig-4 (a) Input image (b) Result of existing method (c) Result of proposed method



(a) (b) (c)

Fig-5 (a) Input image (b) Result of existing method (c) Result of proposed method



(a) (b) (c)

Fig-6 (a) Input image (b) Result of existing method (c) Result of proposed method

These Figures shows better lane detection of input image by using proposed algorithm as compared to previous technique. The previous method not gives good result for curved lane. The proposed method efficiently enhances the visibility of original image by detects curved lanes.

IV. PERFORMANCE EVALUATION

This section include the cross verification between base paper and proposed techniques. Some well-known image performance metrics have been selected to prove that the performance of the proposed method is quite better than the other methods.

4.1 F-measure Analysis:

F-measure is a measure of a test's correctness. It's also called F-score or F_1 score. It considers both precision (p) and recall (r) to calculate the score. It can be interpreted as a weighted average of the precision and recall and also can be viewed as a compromise between recall (r) and precision (p). Where an F-Score reaches its best value at 1 and worst score at 0. It can be calculated as:

$$F_1 = 2.\frac{\text{precision .recall}}{\text{precision +recall}}$$

Where Precision (p) is the number of correct results divided by the number of all returned results or in the field of information retrieval it is defined as the fraction of retrieved documents that are relevant.

$$\text{Precision}= \frac{\text{No .of TP}}{\text{No .of TP} + \text{No .of FP}}$$

Where Recall (r) is the number of correct results divided by the number of correct results that should have been returned.

$$\text{Recall}= \frac{\text{No .of TP}}{\text{No .of TP} + \text{No .of FN}}$$

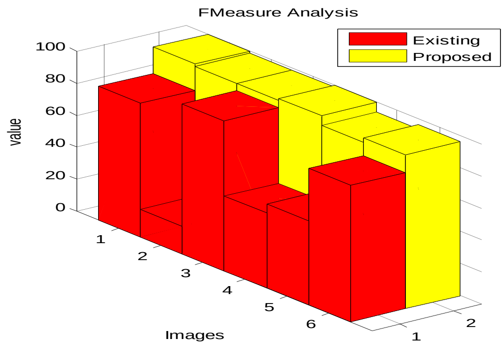
Whereas TP is correctly the true positive, FP is the false positive and FN is the false negative.

Table-4.1.1: F-measure Evaluation

Figures	Existing	Proposed
1	**83.3526**	**99.5879**
2	**17.1934**	**98.5879**
3	**93.6793**	**98.1183**
4	**46.6482**	**99.4085**
5	**52.5398**	**93.1270**
6	**85.0790**	**96.1674**

Table- 4.1.1 demonstrates the evaluation of existing and proposed methods. By using proposed algorithm, the results of F-measure becomes higher than previous results.

The following graph presents the information of F-measure and evaluates it within two statements. Red bar expose the existing method and yellow bar describe the proposed method which is improved as compared to earlier ones.



Graph-4.1.2: F-measure of previous results and proposed results for different images

4.2 Sensitivity Analysis:

Sensitivity measures the proportion of actual positives which are accurately identified and is opposite to the false negative rate. It's also called the true positive rate or the recall rate. It is a statistical measure of the performance of a binary classification test also known in statistics as classification function.

Table-4.2.1: Sensitivity Evaluation

Figures	**Existing**	**Proposed**
1	**0.7146**	**0.9918**
2	**0.0941**	**0.9657**
3	**0.8811**	**0.9631**
4	**0.3042**	**0.9882**
5	**0.3563**	**0.8714**
6	**0.7403**	**0.9262**

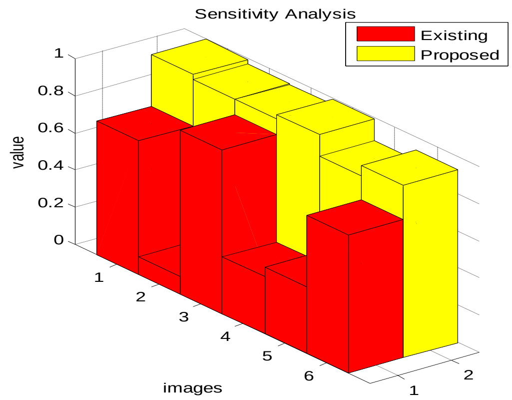
Table- 4.2.1 shows the comparison of sensitivity analysis between existing and proposed method. By using proposed algorithm the value of sensitivity becomes better as compared to previous results. So the main goal as sensitivity is more in every case.

Sensitivity can be calculated as:

$$\text{Sensitivity} = \frac{\text{No.of TP}}{\text{No.of TP} + \text{No.of FN}}$$

Whereas TP is correctly the true positive and FN is the false negative.

The following graph shows the representation of sensitivity value analysis between previous and proposed techniques. Red bar reveal the existing method and Yellow bar define the proposed method which are advanced as compared to prior ones. This increase represents improvement in the objective quality of the image.



Graph-4.2.2: Sensitivity of previous results and proposed results for different images

4.3 Balanced Error Rate (BER) Analysis:

Balanced Error Rate is defined as the average of the error rate of the positive class and the error rate of the negative class. This metric was used because some datasets are unbalanced. To compute the balanced error rate, firstly calculate the Balanced Classification Rate (BCR). Balanced Classification Rate is the average of the sensitivity and the specificity.

$$\text{BCR} = 0.5 * (\text{sensitivity} + \text{specificity})$$

Whereas sensitivity measures the proportion of actual positives which are correctly identified and is complementary to the false negative relation. On the other hand, specificity measures the proportion of negatives which are correctly identified and it's complimentary to the false positive rate.

$$\text{Sensitivity} = \frac{\text{No.of TP}}{\text{No.of TP} + \text{No.of FN}}$$

$$\text{Specificity} = \frac{\text{No.of TN}}{\text{No.of TN} + \text{No.of FP}}$$

So the Balanced Error Rate can be calculated as:

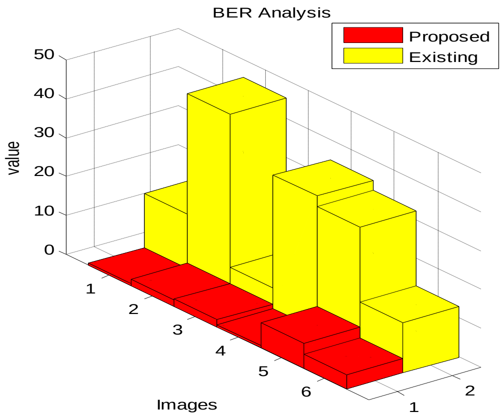
$$\text{BER} = 100^{*}\ (1\text{-BCR})$$

Table-4.3.1: Balanced Error Rate Evaluation

Figures	Existing	Proposed
1	14.2716	0.4104
2	45.2974	1.7160
3	5.9449	1.8470
4	34.7905	0.5880
5	32.1851	6.4310
6	12.9837	3.6911

Table- 4.3.1 illustrates the comparison of balanced error rate between existing and proposed method. By using proposed algorithm the value of bit error rate becomes lower as compared to previous results.

The following graph shows the representation of balanced error rate value analysis between previous and proposed technique. Yellow bar reveal the existing method and red bar define the proposed method which are better as compared to previous ones.



Graph-4.3.2: Balanced Error Rate of previous results and proposed results for different images

4.4 Accuracy:

Accuracy is generally defined as the degree of correctness .It is the proximity of measurement results to the true value or proportion of true results. Both true positive and true negative among the total number of cases observed.

Table-4.4.1: Accuracy Evaluation

Figures	Existing	Proposed
1	0.7237	0.9920
2	0.1076	0.9661
3	0.8864	0.9645
4	0.3257	0.9886
5	0.3863	0.8745
6	0.7577	0.9290

Table- 4.4.1 shows the comparison of accuracy between existing and proposed method. By using proposed algorithm the accuracy becomes higher as compared to previous results.

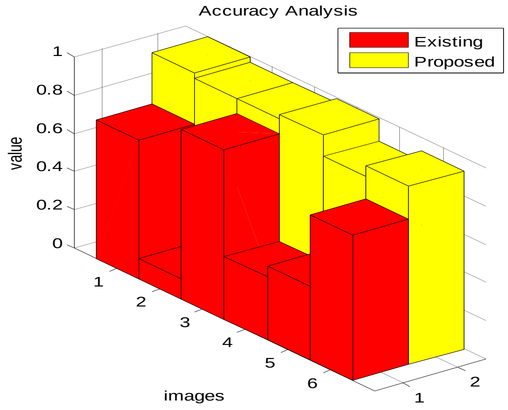
Accuracy can be calculated as by following given formulas such as:

$$A = \frac{\text{No.of TP} + \text{No.of TN}}{\text{No.of TP} + \text{FP} + \text{FN} + \text{TN}}$$

Whereas TP is correctly the true positive, TN is the true negative, FP is the false positive, and FN is the false negative.

It's also defined in terms of sensitivity and specificity, whereas sensitivity measures the proportion of actual positives which are correctly identified and specificity measures the proportion of negatives which are correctly identified .It is used as statistical measure of how well a binary classification test correctly identifies or excludes a condition.

The following graph shows the representation of accuracy value analysis between previous and proposed techniques. Red bar expose the existing method and yellow bar describe the proposed method which are superior as compared to previous ones.



Graph-4.4.2: Accuracy of previous results and proposed results for different images

4.5 Peak signal-to-noise ratio (PSNR) Analysis:

Peak signal-to-noise ratio is defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affect the reliability of its representation. It is used to measure the quality of reconstruction of lossy compression. When comparing compression codecs, it is an estimate to human view of reconstruction quality.

To calculate the peak signal to noise ratio, firstly analyse the mean square error. It can be calculated as by following given formulas such as:

$$PSNR = 10log_{10}\left(\frac{R^2}{MSE}\right)$$

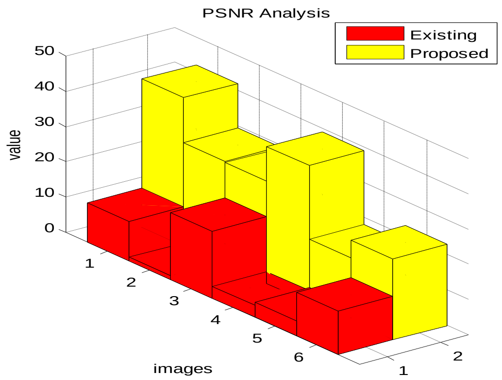
Where R is the maximum fluctuations occurred in the input image data type.

Table-4.5.1: Peak signal-to-noise ratio Evaluation

Figures	**Existing**	**Proposed**
1	**11.1729**	**41.9772**
2	**0.9887**	**29.4042**
3	**18.8898**	**28.9993**
4	**3.4224**	**38.8415**
5	**4.2405**	**18.0282**
6	**12.3145**	**22.9769**

Table- 4.5.1 illustrates the comparison of Peak signal-to-noise ratio between existing and proposed method. By using proposed algorithm the value of PSNR becomes improved as compared to previous results.

The following graph demonstrates the representation of PSNR value analysis between previous and proposed techniques. Red bar expose the existing method and Yellow bar express the proposed methods which are advanced as compared to prior ones.



Graph-4.5.2: PSNR of previous results and proposed results for different images

V. CONCLUSION

Main impact of this paper is to enhance the result of lane colorization algorithm when fog, clatter or any other issue is present in the images. The methods developed so far are work proficiently and give fine results in case when the straight lane road images are present. But difficulty is that they not succeed or not provide efficient results when there are curved lane road images. The proposed method has the capability to hold different kind of conditions i.e. like foggy images, dark time images etc. Also the proposed method is more capable for curved lane images. The experiments results for the road images have shown the major progress of the proposed technique over the existing one.

This work has ignored the use of any evolutionary technique for recognition of the lanes of the road images in efficient way. So in near future we will improve the proposed work by using the ant colony optimization based lane recognition.

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