Lane Detection Using Median Filter, Wiener Filter and Integrated Hough Transform

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***Abstract*— In intelligent transportation systems, intelligent vehicle cooperate with smart infrastructure to achieve a safer environment and better traffic conditions. After analyzing the major causes of injuries and death on roads, it is understandable that one of the main goals in the automotive industry is to increase vehicle safety. In recent development, one of the most frequently implemented solutions for road recognition is the use of camera based systems. Aim of this paper is to integrate cameras in automotive vehicles to increase security and prevent driver's mistakes. In this paper a definition of lane is proposed, and a lane detection algorithm is presented. So far the influence of noise in industrial applications, have been neglected and hence in this paper noise reduction techniques are used i.e. filtering techniques (median and wiener filter). Performance of algorithm is judged in terms of comparative study of median and wiener filters.**

***Index Terms*—lane detection, median filter, wiener filter, edge detection, integrated hough transform.**

I. Introduction

One of the most developed axes of research in automotive solution is passenger's safety. Safety is the main objective of all the road lane detection systems due to the reason is that most of the vehicle road accident happens because of the driver miss leading of the vehicle path. Vehicle crashes remain the leading cause of accident death and injuries of millions of people each year. Most of these transportation deaths and injuries occur on the nation's highways. Indeed, 95% of accidents are due to human behaviour and only 5% to defective vehicles. Moreover, 80% of these accidents involve improper driving reaction, high speed and U-turn. Analyses of these accident scenarios show that more than 40% of the accidents might have been avoided if the vehicle had been equipped with a warning system. This level of safety could rise to 95% if the vehicle could engage a safety driving response in critical situations. Thus, public research groups, automotive manufacturers and suppliers, as well as other research institutions are developing the next generation of driver-assistant system that will enable vehicles to have safer reactions and to decrease road injuries and deaths. Therefore, a system that provides a means of warning the driver to the danger has the potential to save a considerable number of lives. One of the main technologies involves in these takes computer vision which become a powerful tool for detection of lanes. This paper presents vision- based approach capable of reaching a real time performance in lane detection after applying the edge detection and Hough transform.

II. The Proposed Algorithm

The proposed algorithm structure is shown in Fig. 1. A CCD camera is fixed on the front-view mirror to capture the road scene. In this paper, it was assumed that the input to the algorithm was a 620x480 RGB color image. Therefore the algorithm works to convert the image to a grayscale image in order to minimize the processing time. Secondly, in presence of noise, the image will hinder the correct edge detection. Hence, Filtering techniques i.e. median filter and wiener filters are applied one by one to make the edge detection more accurate. Then the edge detector was used to produce an edge image by using canny edge detector with an automatic thresholding to obtain the edges. It has reduced the amount of learning data required by simplifying the image edges considerably. Then edged image has been sent to the line detector which produces a right and left lane boundary segment. The projected intersection of these two line segments was determined and was referred to as the horizon. The lane boundary scan used the information in the edge image detected by the Hough transform to perform the scan. The scan returned a series of points on the right and left side.

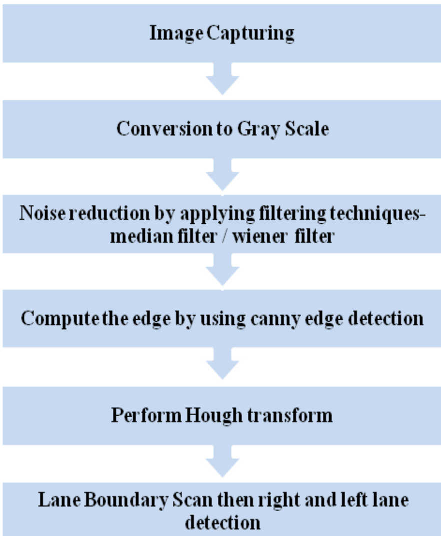

Figure. 1. An over view of the proposed algorithm

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A. Image Capturing

The input data was a color image sequence taken from a moving vehicle. A color camera was mounted inside the vehicle at the front-view mirror along the central line. It took the images of the environment in front of the vehicle, including the road, vehicles on the road, roadside. The on-board computer with image capturing card captured the images in real time, and saved them in the computer memory. The lane detection system read the image sequences from the memory and started processing.

B. Conversion to Gray Scale

To retain the color information as well as to segment the road from the lane boundaries using the color information, edge detection becomes difficult and consequently effects the processing time. In practice the road surface can be made up of many different colors due to shadows, pavement style or age, which causes the color of the road surface and lane markings to change from one image region to another. Therefore, color image were converted into grayscale. However, the processing of grayscale images became minimal as compared to a color image.

C. Noise Reduction

Noise is a real world problem for all systems including computer vision processing. The noise must be eliminated in the developed algorithm. As presence of noise in proposed system will hinder the correct edge detection. Hence noise removal is a pre requisite for efficient edge detection with the help of filtering techniques. In this research, noise reduction of the images is done at first. Considering salt and pepper noise in the images, noise will be reduced by using filtering techniques. Comparison will be drawn among the two techniques i.e. median filter and wiener filter.

D. Edge Detection

Lane boundaries are defined by sharp contrast between the road surface and painted lines or some types of non-pavement surfaces. These sharp contrasts are edges in the images. Therefore edge detectors are very important in determining the location of lane boundaries. It also reduces the amount of learning data required by simplifying the image considerably, if the outline of a road can be extracted from the image. The edge detector was implemented for this algorithm. The one that produced the best edge images from all the evaluated edge detectors was the ‘canny’ edge detector. It was important to have the edge detection algorithm that could be able to select thresholds automatically however, the automatic threshold used in the default Canny Algorithm produced edge information that is far from actual threshold. A slight modification to the edge detection in canny has produced more desirable results. The only changes necessary were to set the amount of non-edge pixels of the highest and lower thresholding to the best value that has provided more accurate edges in different conditions of image capturing environment.

E. Perform Hough Transform

The Hough transform as it is universally used today was invented by Richard Duda and Peter Hart in 1972, who called it a "generalized Hough transform” after the related 1962 patent of Paul Hough. Hough transform is one of the powerful global methods for shape detection such as detecting lines, curves and ellipses. It is performed after Edge Detection. According to Hough Transform “Each pixel in image space corresponds to a line in a parameter space (Hough space)”.

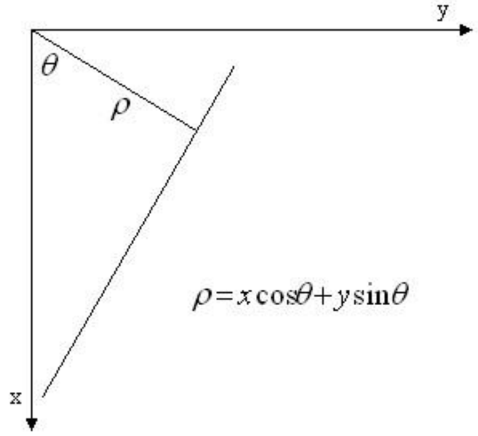

Figure. 2. Hough transform for detecting straight lines

In reality, any line that falls outside a certain region can be neglected. For example a horizontal line is probably not the lane boundary and can be rejected. The restricted Hough transform was modified to limit the search space to 45° for each side. Also the input image is splitted in half yielding a right and left side of the image. Each the right and left sides are searched separately returning the most dominant line in the half image that falls within the 45° window. The horizon is simply calculated using the left and right Hough lines and projecting them to their intersection. The horizontal line at this intersection is referred to as the horizon

F. Lane Boundary Scan

The lane boundary scan phase uses the edge images, the Hough lines and the horizon line as input. The edge image is what is scanned and the edges are the data points it collects. The scan begins where the projected Hough lines intersect the image border at the bottom of the image. Once that intersection is found, it is considered the starting point for the left or right search, depending upon which intersection is at hand. From the starting point, the search begins a certain number of pixels towards the center of the lane and then proceeds to look for the first edge pixel until reaching a specified number of pixels after the maximum range.

III. Results and Discussion

This section evaluates the overall performance of the system, after solving most of the problems discovered in earlier developed stages of the scheme. The performance of the algorithm is evaluated qualitatively in terms of accuracy, specificity, BER, PSNR.

This section contains different images which are tested on the designed algorithm.

TABLE I: INPUT DATA SET

Image	**Size in (KBs)**	**Extension**
Image 1	24	jpg
Image 2	1386	bmp
Image 3	2132	bmp
Image 4	842	bmp
Image 5	792	bmp
Image 6	2085	bmp
Image 7	2713	bmp
Image 8	727	bmp
Image 9	200	jpg
Image 10	167	jpg
Image 11	41	jpg
Image 12	26	jpg
Image 13	176	jpg
Image 14	35	jpg
Image 15	109	Jpg

A. Comparative Study of Wiener Filter and Median Filter

Figures below show the comparison of image implemented on the two filtering techniques i.e. median filter and wiener filter.

1) Wiener filter

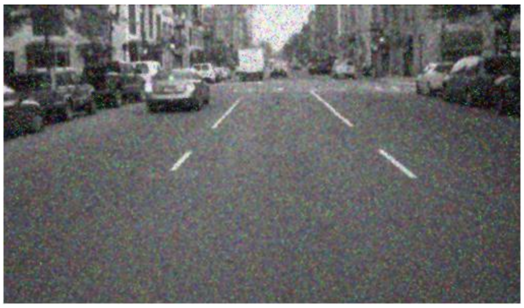

Figure. 3. (i) Input image

Figure. 3. (ii) Grayscale image

Figure. 3. (iii) Binary image

Figure. 3. (iv) Smoothed binary image

Figure. 3. (v) Canny edge detected image

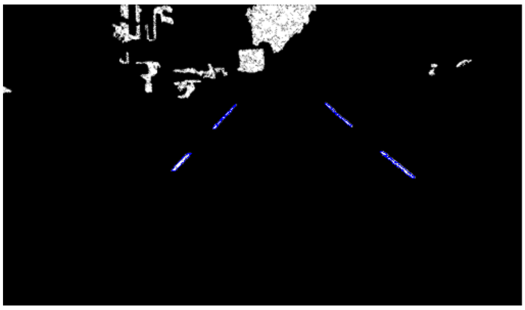

Figure. 3. (vi) Smoothed binary image

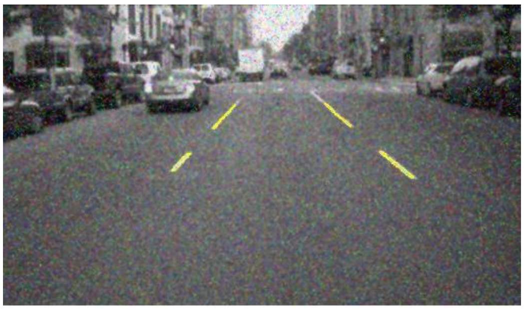

Figure. 3. (vii) Output image

2) For median filter

Figure. 4. (i) Input image

Figure. 4. (ii) Gray scale image

Figure. 4. (iii) Binary image

Figure. 4. (iv) Smoothed binary image

Figure. 4. (v) Canny edge detected image

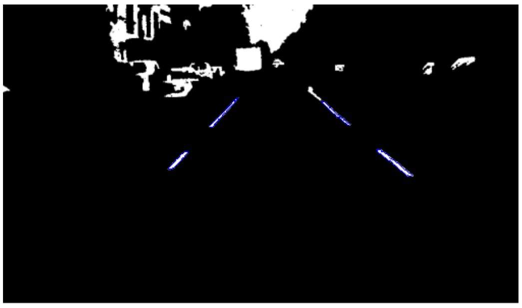

Figure. 4. (vi) Smoothed binary image

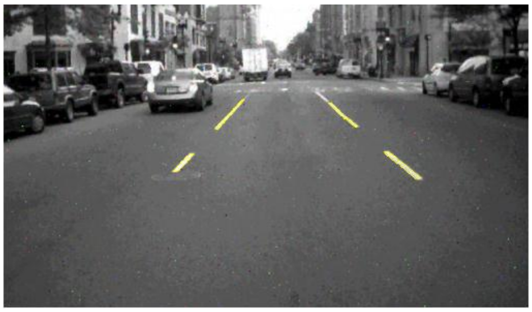

Figure. 4. (vii) Output image

B. *Performance Analysis*

This section contains the performance comparison of the proposed algorithm and existing algorithms by taking different performance parameters. The overall objective of this chapter is to prove that the proposed algorithms provide more accurate results than the existing algorithms.

1) Accuracy analysis

Accuracy is need to as much as possible. Table II is showing the accuracy analysis of the two filtering techniques. The accuracy of the median filter is more than 99.94 in the most of cases therefore the proposed algorithm is quite accurate than the others in most of the cases. While comparing, the two filtering techniques it is found that accuracy of median filter is much better than wiener filtering technique.

TABLE II: ACCURACY ANALYSIS

Image	Median filter	Wiener filter
Image 1	99.89	99.77
Image 2	99.92	99.33
Image 3	99.73	99.82
Image 4	99.90	99.94
Image 5	99.87	99.63
Image 6	99.88	99.94
Image 7	99.81	99.77
Image 8	99.87	99.93
Image 9	99.82	99.90
Image 10	99.73	98.90
Image 11	99.73	99.48
Image 12	99.82	99.88
Image 13	99.81	99.85
Image 14	99.93	99.96
Image 15	99.77	99.87

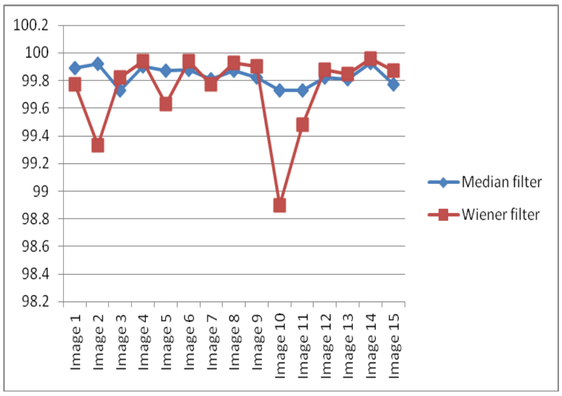

Figure 5.1. Accuracy analysis

Fig. 5.1 has shown the accuracy analysis of the proposed and exiting techniques. Fig. 5.1 has clearly shown that the accuracy in the median filter is maximum than using the wiener filter.

2) Specificity evaluation

As specificity needs to be maximized therefore it is proved that the Specificity of the proposed technique in case of the input images shown in Table I has given objectively effective results than the surviving technique.

TABLE III: SPECIFICITY EVALUATION

Image	Median filter	Wiener filter
Image 1	0.85	0.52
Image 2	0.97	0.35
Image 3	0.99	0.99
Image 4	0.96	0.97
Image 5	0.99	0.94
Image 6	0.61	0.61
Image 7	0.89	0.83
Image 8	0.92	0.95
Image 9	0.99	0.99
Image 10	0.99	0.89
Image 11	0.98	0.93
Image 12	0.54	0.25
Image 13	0.91	0.90
Image 14	0.77	0.70
Image 15	0.57	0.58

TABLE IV: BIT ERROR RATE (BER) EVALUATION

Image	**Median filter**	**Wiener filter**
Image 1	7.56	24.10
Image 2	1.48	32.50
Image 3	0.70	0.58
Image 4	1.89	1.54
Image 5	0.67	2.88
Image 6	19.48	19.28
Image 7	5.55	8.39
Image 8	3.76	2.72
Image 9	0.43	0.28
Image 10	0.70	5.31
Image 11	1.06	3.24
Image 12	23.02	37.34
Image 13	4.47	4.86
Image 14	11.63	15.27
Image 15	21.38	21.04

Table III has shown the Specificity exploration of the two filtering techniques. It is clearly shown that in many cases of median filter we have achieved specificity up to .99 which is almost equal to 1. Therefore we can justify in terms of specificity that the proposed algorithm is quite effective and giving accurate results.

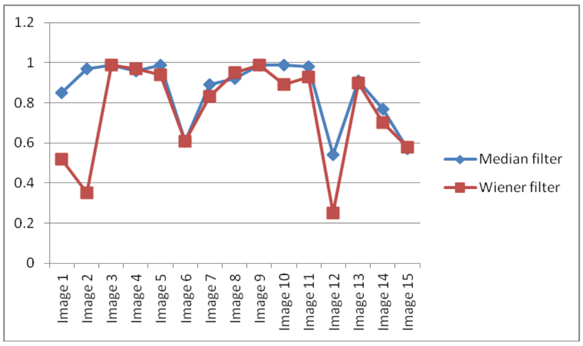

Figure 5.2. Specificity exploration analysis

3) Bit error rate (BER) evaluation

As required BER need to be reduced. It is clearly shown that BER is quite less in proposed algorithm reason behind this is the median filter.

Table IV has shown the BER investigation of the two filtering techniques. It is found that the BER of the proposed procedure in case of the input images shown in Table I has given fairly effective outcomes than the existing technique.

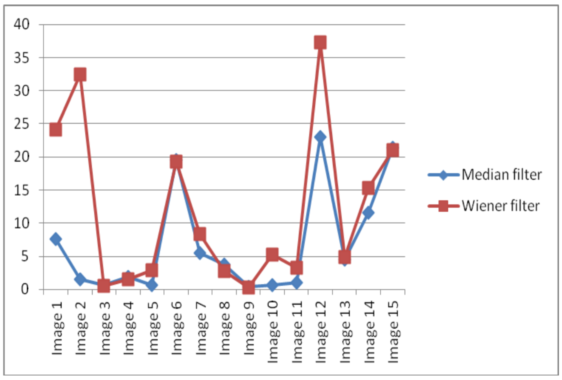

Figure 5.3. Bite error rate (BER) analysis

Fig. 5.3 has shown the Bit error rate analysis of the proposed and exiting techniques. Fig. 5.3 has clearly shown that the BER in the median filter is minimum than using the wiener filter. So it has shown that the proposed algorithm is quite effective and produces effective results than available technique.

4) PSNR evaluation

Table V has shown the PSNR examination of the planned and traditional method. It is proved that the PSNR of the proposed technique in case of the input images shown in Table I has specified quantitatively improved consequences than the persisting technique.

TABLE V: PSNR EVALUATION

Image	**Median filter**	**Wiener filter**
Image 1	26.72	23.45
Image 2	28.10	18.79
Image 3	24.14	25.73
Image 4	27.40	29.30
Image 5	26.59	21.79
Image 6	26.25	29.08
Image 7	24.27	23.42
Image 8	26.07	28.42
Image 9	25.97	28.28
Image 10	24.05	17.35
Image 11	23.64	20.46
Image 12	24.45	26.33
Image 13	24.41	25.47
Image 14	28.31	31.43
Image 15	23.40	25.99

Fig. 5.4 has shown the PSNR examination of the planned and available filtering methods. It is proved that the PSNR of the proposed technique in case of the input images shown in Table I has specified quantitatively improved consequences than the persisting techniques. Hence PSNR of median filtering technique is quite better whereas in case of wiener filtering technique the graph is almost fluctuating to low values than high.

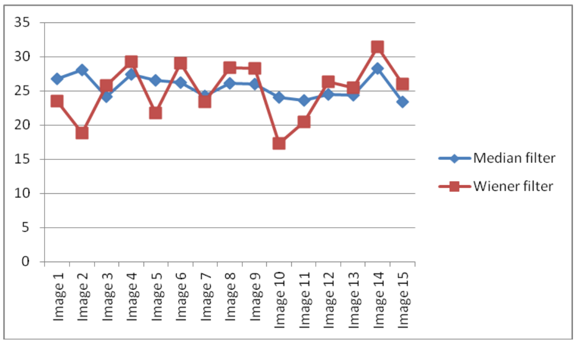

Figure 5.4. PSNR comparison

IV. Summary and Conclusion

Vehicle safety is one of the most active areas of research for the automotive industries. Therefore, solutions for "intelligent" vehicles are pointing out. In this paper, the algorithm was implemented using Matlab 7.11 version. A database including a growing number of image and video frames is set up for the experiment. All these images are taken in highways and normal roads, dashed markings, straight and curved roads in different environmental conditions (sunny, cloudy, night time, shadowing, rainy). A definition of "lane" has been provided, in order to determine precisely what the algorithm of lane detection is expected to find. In order to see the evolving scene, the camera and the processing platform have to be capable of taking and processing rapidly the sequence of images. A solution has been proposed to avoid large computation on the whole image, and different propositions of lane detection have been described. Several criteria had also been developed to weight the reliability of the lane detection algorithm. In this paper, a real time vision-based lane detection method was proposed. As mentioned above the system uses a series of images. Canny operator was used to detect edges that represent road lanes or road boundaries. The lanes were detected using Hough transformation with restricted search area. The proposed lane detection algorithm can be applied in both painted and unpainted road, as well as slightly curved and straight road. The experimental results showed that the system is able to achieve a standard requirement to provide valuable information to the driver to ensure safety.

V. Future Work

Much work could be done to increase the robustness of this algorithm and to improve its performance overall. However, still some problems did not solved yet such as the accurate detection of the lanes under heavy rain therefore, we need to improve the algorithm to overcome such problem.

To start with, implementation of the algorithm onto a FPGA or DSP system would be needed before it could be used in practice in a vehicle. Some changes could also be done to the different algorithms employed by each module. When a boundary is found that has not the same features as the road surface or road markings (e.g. different colour, shape, texture, etc) a warning could be issued to the driver. The lane detection algorithm could be improved for different lighting conditions by designing a better feedback loop for the colour to binary conversion.

Looking at the larger picture, research into other vision based technologies for the system, e.g. infrared could yield better performance by being able to detect animals or pedestrians body heat signature if they were in the path of the vehicle. Combining the vision based approach with radar for example, could give the best of both worlds: biological object detection, vision in foggy/rainy conditions, the distant image resolution and accuracy of radar, and so on. The detection of animals or pedestrians could be used in conjunction with pedestrian safety features on the vehicle such as the "Active Bonnet System" on the Citroen C5, to increase their effectiveness. Communication between vehicles could increase the effectiveness of the algorithm by combining the data received by neighbouring vehicles. Using a mono camera to detect the time to collision of an object could also be investigated. This could use local motion field measurements to determine whether and when a collision is about to occur.

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