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VIGILANT SYSTEM FOR VEHICLES BY LANE DETECTION

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ABSTRACT

In Vigilant system (vs), Lane Detection and tracking on the road side are very important treatment to locate the road lanes and to track its position. The cardinal aspiration of this system is to handover a warning to the drivers in case of is in danger of leaving road lanes unintentionally. In this paper, vision based system is used to detect the road marking lanes which is capable of reaching real time environments including the robustness to lightening changes, shadows and other perspective influences. The system achieves the video sequence from the camera mounted on the vehicles and then applying few processes in order to detect the lanes. These detected lane parameter information are filtered and then extracted by 2D FIR filter before the Hough transform algorithm was implemented. The System detects and tracks the road lane markers in video sequencing and for the purpose to notifies the drivers if they are moving across the lanes, in order to collision avoidance and mitigation in future. Thus the system was tested and the experimental result shows that the proposed work was robust and efficient enough for real time environment.

IndexTerms—Vigilant system, Lane Detection, Warning, vision based system, intelligent system.

1. INTRODUCTION

Active safety system, Intelligent Vehicle Technology (IVT) is an important part of Intelligent Transport System (ITS) has been developed to reduce accident rates and to improve the efficiency of the traffic utilization. This type of active safety system based on the environment recognizes to detect critical situations or inevitable crashes. Although, a more persuasive sense to build intelligent vehicles is to improve the safety conditions either by whole or partial automation of driving tasks. Among these tasks, the road lane detection took a serious role in vigilant system that affords necessary information such as lane structure and vehicle position relative to the lane. The basic key core of this (IVT) technology is make use of machine for recognize the road traffic environments. This paper has been developed vision-based road detectionalgorithms to avoid vehicle crash on the road. Safety is the main objective of all the road lane detection systems due to the reason is that most of the vehicles road accident happens because of the driver miss leading of the vehicle path.

This paper demonstrates vision-based approach competent of reaching the performance of real time environment by detecting and tracking the road lane marker which is more enough to meet the requirements including the impacts of light, shadows, water, snow and other perspective influence. The road lane marker are extracts by introduces the theory of algorithms results in lane marking line recognition, including image binarization, edge detection, and lane extraction. Thus the system explains lane departure warning system which detects the lane markings on the road that warns the driver in case of a departure. The system illustrates how to use the Hough Transform, Hough Lines and Kalman Filter blocks to create line detection and tracking algorithm. [1]- [4].

2. RELATIVE WORKS

Assurance for safety and reduce the road accidents, thereby saving the lives are of the great interest in the context of vigilant system. Therefore, presently many different vision-based road detection algorithms have been developed to avoid vehicle crash on the road [5]. Among these algorithms image analysis and recognition field uses edge detection methods for label the objective region and grasp the information of the road shape.

The basic idea of the edge detection is to locate the edge position and separate from distinct background. Edge detection is the initial step for obtaining information from images. Edge detection is the fundamental tool in image processing, vision-based techniques notably in the areas of features detection and extraction which aims at identifying points in the images at which image brightness changes sharply or, more formally, has discontinuities [6]. Classical methods of edge detection involve convolving the image with an operator (2-D Filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There is an extremely large number of edge detection to be sensitive to certain types of reason.

Schemes involved in the selection of an edge detection operator include,

- Filtering: Filter image to improve the performance of the edge detector with respect to noise.
- Enhancement: Filter is applied to get the quality of the edge image. Emphasize Pixels having significant change in local intensity.
- Edge Detection: Identify Edges –Threshold. Determine which edge pixel should be discarded as noise and which should to retain.
- Localization: Locate the edge accuracy; estimate the edge orientation.

3. EDGE DETECTION METHODOLOGIES

There are many ways to perform edge detection. However, the majority of the different methods may be grouped in to three categories,

A. *Edge Detection Based on Gradient Method-First Order Derivative Method*

The gradient method detects the edge by looking for the maximum and minimum in the first derivative of the image.

If I(i,j) be the input image ,then the following formula is used to derive the gradient image ,

$$\nabla \mathrm{I}(\mathrm{i},\mathrm{j}) = \hat{\imath}\frac{\partial I(i,j)}{\partial i} + \hat{\jmath}\frac{\partial I(i,j)}{\partial j} \text{Where, } (1)$$

$\frac{\partial I(i,j)}{\partial i}$ is the gradient of i direction.

$\frac{\partial I(i,j)}{\partial j}$ is the gradient of j direction.

The gradient magnitude of the image can be computed by the given formula,

$$|G| = \sqrt{\left(\frac{\partial I}{\partial i}\right)^2 + \left(\frac{\partial I}{\partial j}\right)^2} \quad (2)$$

(Or)

$$|G| = \sqrt{Gi^{2+}}Gj^2 \quad (3)$$

The gradient direction of the image can be computed by the given formula,

$$\theta = \tan^{-1}\frac{Gj}{Gi} \quad (4)$$

The above stated formula is perpendicular to the direction of the edge.

Classical Operator

Robert, Sobel, Prewitt are the methods comes under first order edge detection or Edge based gradient method, which is also classified as classical operator. But these methods are very sensitive to noise.

i. *Robert Operator*

This method estimates the sum of the squares of the difference between diagonally adjacent pixels through discrete differential and then calculates the approximate value of the gradient of the image.

The Convolution mask of this operator becomes,

$$D_x = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \quad (5)$$

$$D_y = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \quad (6)$$

The main advantage of this method is simplicity but it is highly sensitive to noise and is not compatible with today’s technology.

ii. *Sobel Operator*

Sobel operator is also differentiation operator (discrete) used to compute an approximation of the gradient of image intensity function for edge detection.

The convolution mask of this sobel operator smoothes the image by some amount, hence it is less susceptible to noise. But it produces thicker edges. So edge localization in this method is very poor. The convolution mask becomes,

$$D_i = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad (7)$$

$$D_j = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \quad (8)$$

This operator is calculated at the center pixel of the mask.

iii. *Prewitt Operator*

Prewitt operator is similar to sobel operator but uses

slightly different mask.The convolution mask of this operator becomes,

$$D_i = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \quad (9)$$

$$D_j = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \quad (10)$$

Prewitt edge detection operator gives better performance than the sobel operator.

B. *Edge Detection Based on Laplacian Method-Second Order Derivative Method*

The Laplacian method searches for the zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location. This function indicates the presence of maxima.

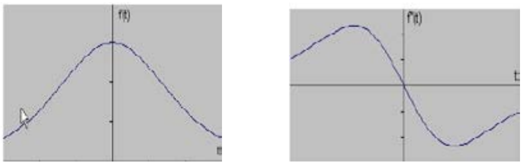


Fig.1. Zero crossing of the image

The Laplacian operator ∇^2 for 2D image (i,j) is defined by following formula

$$\nabla^2 = \mathrm{I(i,j)} = \frac{\partial^2}{\partial x^2}\,\mathrm{I(i,j)} + \frac{\partial^2}{\partial y^2}\,\mathrm{I(i,j)} \quad (11)$$

The convolution mask becomes,

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad (12)$$

This operator is very susceptible to noise, hence it required filtering process. The Laplacian operator uses Gaussian filter.

Laplacian of Gaussian method is also called Marr-Hildreth edge detector defined by following formula,

$$LoG(i,j) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{i^2+j^2}{2\sigma^2}\right] e^{-\frac{i^2-j^2}{2\sigma^2}} \quad (13)$$

Laplacian of Gaussian method suffers from mainly three limitations.

1. It generates response that do not corresponding to edge, so called "false Edges".
2. Localization error may be severe at the curved edges.
3. It requires large computational task for large edges.

C. *Edge Detection Based on Optimal Method*

It is important that edges occurring in images should not be missed and that there be no responses to non edges. The criterion is that the edge points be well localized. Example for the optimal edge detector is Canny method.

Optimal edge detector depending on,

- Low error rate: Edges should not be missed and there must be spurious responses.
- Localization: Distance between points marked by the detector and the actual center of the edge should be minimum.
- Response: Response should be only one to a single edge.

4. OVERVIEW OF SYSTEM ARCHITECTURE

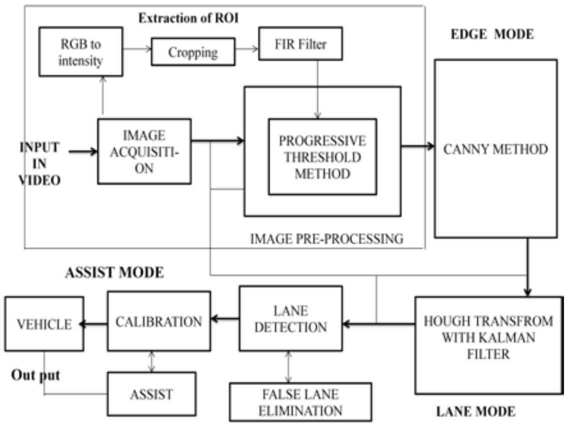


Fig. 2. Architecture diagram for vigilant system

The overall architecture structure is shown in Figure.2. A CCD camera is fixed on the front-view of the vehicle to capture the road lane maker environment. In this paper, the input of the system in video sequence which was given to the image acquisition unit for make it out an images. The input image for the extraction of ROI (Region of Interest) mode was RGB color image. Therefore the first thing the algorithm does is to convert the image to a grayscale image in order to minimize the processing time. The grayscale image is sufficient to meet the requirements [7]. Then crop the grayscale image as for the user need. Secondly, Progressive threshold method [8] is used for the binarization. It is an image segment technique, which is aimed to extract the meaningful part of the image, as presence of noise in the image will hinder the correct edge detection. Therefore, we apply FIR filter to make image for the edge detection more accurate. Then the edge detector is used to produce an edge image by using canny method with automatic thresholding to obtain the edges, it will reduce the amount of learning data required by simplifying the image edges considerably. Then edged image sent to the line detector after detecting the edges which will produces a right and left lane boundary segment. The lane boundary scan uses the information in the edge image detected by the Hough transform [7] to perform the scan. The scan returns a series of points on the right and left side. Finally pair of hyperbolas is fitted to these data points to represent the lane boundaries. For visualization purposes the hyperbolas are displayed on the original color image. After the detection of the lane marker we, have to detect the true lanes by the technique of false lane elimination. It is very useful in situations where other vehicles or object which may resemble like a lane may interfere with the system's lane detecting system.

Then the system should assist the vehicle for the purpose to notify the drivers if they are moving across the lanes, in order to collision avoidance and mitigation in future. Most of the vehicle road accident happens because of the driver miss leading of the vehicle path. Thus the vigilant system explains lane departure warning system which detects the lane markings on the road that warns the driver in case of a departure.The system illustrates how to use the Hough Transform, Hough Lines and Kalman Filter blocks to create line detection and tracking algorithm.

5. OVERVIEW OF ALGORITHM FLOW

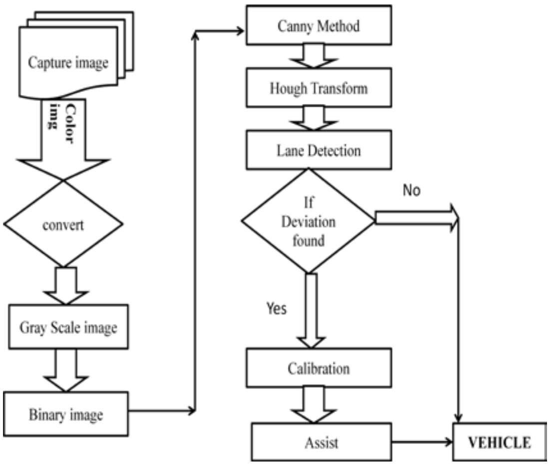


Fig .3.Flow diagram of vigilant system

The above figure.3 describes the flow diagram of the vigilant system

A. *Image capturing*

The input data is a color image in video sequence taken from a moving vehicle. A color camera is mounted inside the vehicle. It takes the images of the environment in front of the vehicle, including the road, vehicles on the road, roadside, and sometimes incident objects on the road. The on-board computer with image capturing card will capture the images in real time (up to 30 frames/second), and save them in the computer memory[7]. The lane detection system reads the image sequence from the memory and starts processing

B. Conversion of Grayscale image

Use of the color image is very difficult to provide the information of the road lanes due to the impacts of lighting, shadows. General image processing pictures use gray images, since the each pixel of gray image shares one byte of a 24-bit true-color image occupies three bytes. Taking into account the real-time image processing requirements with practicality, the gray image is sufficient to meet the requirements [7]. This function transforms a 24-bit, three-channel, color image to an 8-bit, single-channel grayscale image by forming a weighted sum of the Red component of the pixel value * 0.3 +Green component of the pixel value * 0.59 + Blue component for the pixel value *0.11 the output is the gray scale value for the corresponding pixel[6][8].

C. *Binarization technique*

Binarization is the technique of converting the grayscale image into binary image. The aim of this technique is to extract the meaningful part of the image. It is about the separation of lane markings and road area. The binarization method is to judge the gray value of each pixel and determine a threshold value [6]. The threshold value cannot be fixed, hence it cannot meet the requirements for each frame exactly the same due to the impact of the light, shadow, snow, and other perspective influence.

This paper proposed the Progressive threshold method. It treats each single line of the image unit to reduce the impact of contrast changes. Progressive threshold segmentation method is to conduct the optimal threshold segmentation based on each line of the image [9].Fig 4. Shows the threshold value selection of the image. To reduce the time cost and redundant part of image, the upper halfregion of the image which is not the road region is set to zero (black).Fig 5.Describes the resultant image of the binarization technique using Progressive threshold method.

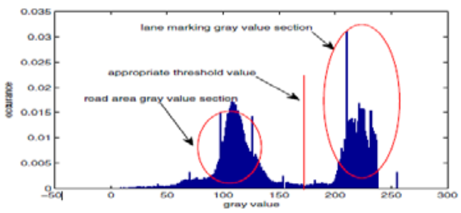
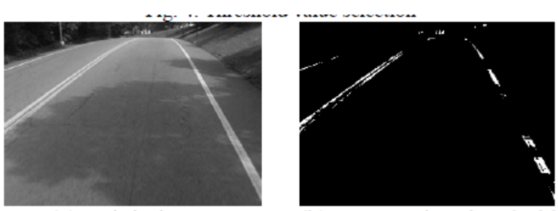


Fig.4.Threshold value selection.



(a) Origin image (b) Progressive threshold

Fig.5. Result of Progressive threshold binarization method

D. *Edge Detection*

The purpose of the edge detection is to make the pixels located on the edge position can be separate and distinct from backgrounds. Lane boundaries are defined by sharp contrast between the road surface and painted lines or some type of non-pavement surface. These sharp contrasts are edges in the image. 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 implemented for this algorithm and the one that produced the best edge images from all the edge detectors evaluated was the 'canny' edge detector [10].

Canny method is an optimal edge detection technique as provide good detection, clear response and good localization. It is widely used in current image processing techniques with further improvements. The implementation of this method has following criteria,

1. Noise is filtered out by using Gaussian filter. The edge width should be carefully chosen.
   The smooth resultant image is given by,
   $\mathrm{F(i,j)} = \mathrm{G} * \mathrm{I(i,j)}$ (14)
2. Edge strength is found out by taking the gradient value of the image.
   A Roberts mask or Sobel mask can be used
   $|G| = \sqrt{Gi^{2+}Gj^2}$ (15)
3. Find the edge direction by the formula,
   $\theta = \tan^{-1}\frac{Gj}{Gi}$ (16)
4. Resolve the Edge
5. Non-maxima suppression tracks along the edge direction and suppress any pixel value not considered to be edge. Gives the thin line for edge.
6. Use double/hysteresis thresholding to eliminating streaking. Instead of choosing a single threshold, for avoiding the problem of streaking two thresholds t_{high}andt_{low} are used.

For a pixel M (i, j) having gradient magnitude G following conditions exists to detect pixel as edge:

_ If G <t_{low}than discard the edge.

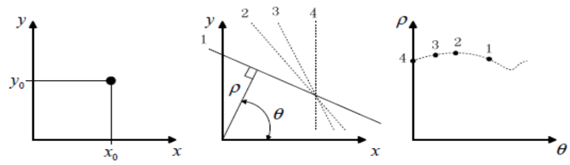
_ If G > than t_{high}keep the edge.

_ If t_{low}< G < and$t_{high}$and any of its neighbors in a 3 ×3 region around it have gradient magnitudes greater thant_{high}, keep the edge.

E. *Lane determination*

After Road image binarization and the edge detection, we need to extract the lane information. It is Hough transformation that is commonly used to extract the straight lane marking line. This method can easily connect the discontinuous pixel points, and is barely affected by noise points and intermittent line. The basic principle of Hough transformation is to utilize the dual relationship of two spaces, solving the problem of the original space after transformed to its parameter space, since it is easier to solve the problem in parameter space. Fig.8 shows the process of transformation. Practically, the parameterized method is that every single line represents one point (ρ,θ)in polar coordinate [6]. The transform relation can be expressed as:

$$\rho = x\cos\theta + y\sin\theta \quad (17)$$



$$r = x.\cos\theta + y.\sin\theta$$
$$y = -\frac{\cos\theta}{\sin\theta} + \frac{r}{\sin\theta}$$

Fig 6. Hough transform

F. *Calibration*

- The road is divided into 5 regions by the system they are, The region 1 represents that the lane is at deep left, here it requires major correction.
- The region 2 represents that the lane is at left,here it requires a minor correction.
- The region 3 represents that the lane is at normal position and no need of correction is required at this suitation.
- The region 4 represents that the lane is at right, here it requires a minor correction.
- The region 5 represents that the lane is at deep right and here it requires a major correction.

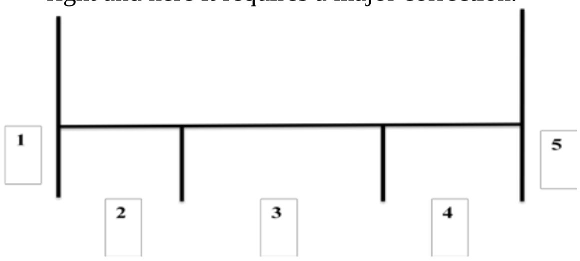


Fig 7.Departure detection and Message generation

G. *Assistance*

The lane location is compared with all the possible intervals. According calibration, if the vehicle moves out of the normal region the system gives the warning signal to the drivers of the vehiclefor the purpose to reduce the vehicle crashes.

6. EXPERIMENTAL RESULTS

In this paper, the algorithm was implemented in Intel core2 Duo 2.5 GHZ computer using Matlab 7 associate with RS232 serial port interface. For the testing approach different image sequence taken from the highway roads in different environmental visibility conditions. Form the result we can observe that the lane detection boundaries are successfully extracted, which indicate the robustness and real time performance of the algorithm with less processing time and good quality. The higher the speed the more important it is to react quickly. The Vigilant system provides support when your vehicle may stray out of its lane of travel unintentionally.

However should your vehicle leaves its lane the system warns the driver through audio signal to stay back to original position.

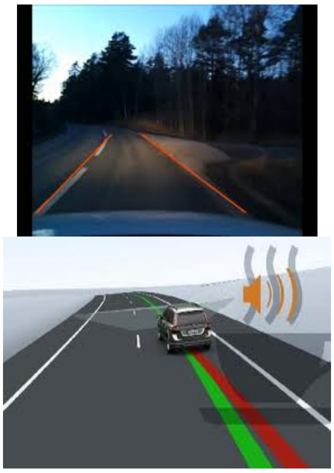


Fig 7. Results - Lane boundary detection and indication of warning signal when leaving the Lane.

7. CONCLUSION

In this paper, Vigilant System for Vehicles by Lane Detection based on video sequences taken from a vehicle driving on highway was proposed. As mentioned above the system implemented some algorithms in series of images taken to detect the Lane Marking Lines of the road. This algorithm meets all the requirements of the road environment. Since the lanes are normally long and smooth curves, we consider them as straight lines within a reasonable range for vehicle safety. The lanes were detected using Hough transformation Method. After that divides and calibrate the road region with the possible intervals and thus the system gives alert signal to the vehicle while moving out of the normal region of the road segment without intension. This paper meets the basic requirements of the automotive active safety navigation. This system can be enhanced by automating to its next level. The system can be fully automated and can be driven by it using radar and advanced systems in future.

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