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Lane Departure Detection and Transmisson using Hough Transform Method

***Abstract**. Vehicles need to be re-advancing by video transmission among vehicles for safety and cooperative deriving. The video images captured from camera could help the driver to monitor the surroundings as well as transmit the compressed images over vehicular communication network. Video over wireless communication has a lot of potential applications in intelligent transportation systems (ITS).Video streaming utilizes high bandwidth data links to transmit information. The high-bandwidth systems required larger equipment, better line-of-sight, and more complex mechanism for reliable transmit ion over the network. The intended platform for the system described in this study, is to develop a software defined algorithm for automatic video compression and transmission. The proposed algorithm is able to robustly find the left and right boundary of the lane using Hough Transform method and transmit over the network. Therefore the limitations of high-bandwidth equipment become more significant in a tactical scenario. The results show that the proposed method works well on marked roads and transmission in various lighting conditions.*

***Streszczenie**. W artykule przedstawiono algorytm kompresji i transmisji obrazów do zastosowania w komunikacji bezprzewodowej w sieci samochodowej. Przy pomocy transformacji Hough algorytm określa lewą i prawą granicę pasa i przesyła dane do sieci. Przeprowadzono badania weryfikujące działanie algorytmu, które wykazały jego skuteczność na oznaczonych drogach przy różnych warunkach oświetlenia. (**Zastosowanie transformacji Hough w detekcji wyjazdu z pasa i transmisji danych**).*

Keywords: Video Transmission, Wireless Communications, Lane departure, Segmentation, Filter and Thresholding.
Słowakluczowe: transmisja wideo, komunikacja bezprzewodowa, wyjazd z pasa, segmentacja, filtracja, progowanie.

Introduction

Now a day's we observe that most researchers focused on increasing need for traffic safety systems to reduce the risk of accidents. There are large numbers of vision based systems for vehicle control, collision avoidance and lane departure warning, which have been developed during the last two decades [1]-[3]. Recently, many Driver Assistance systems (DAS) are emerging to work in harmony with human drivers [4], e.g. Forward Collision Warning System (FCWS) and on-board Lane Departure Warning System (LDWS). Such systems can be used to help preventing driver's mistakes and reduce traffic accidents effectively [5].

The authors in [6] combined the knowledge-based methods such as shadow detection, entropy analysis and horizontal symmetry measurement for mid-range and distant vehicle detection without prior knowledge about the road geometry. The mentioned systems have lacked of accuracy and environmental effects depending on their production. Therefore, these systems were failed in providing a full collision avoidance system to the vehicle. The systems having higher accuracy and technology need expensive investment and good maintenance.

In the past decade, many digital devices were developed and implemented [7]. Most of them were costly electronic devices; the categories of these devices are vehicular-based driving aids such as GPS navigation systems, Transponders and Mobile phones. Road-based driving aids are inductive loop detectors and sensors, traffic surveillance systems such as closed-circuit television (CCTV) [8][9]. With the availability of GPS systems, it is practical to locate a vehicle with certain accuracy. However, at the time of lane departure the GPS data do not provide the exact positions of vehicles, due to degradation or multipath problems. Therefore, it is challenging to determine the exact lane position that a vehicle is departing [10], [11].

A lane departure problem is defined using the origin-destination matrix, with the objective of reducing the unnecessary crossings on the road [12]. Their lane departure strategy assigned a lane to each vehicle based on its origin and destination. The simulation results showed the effects of scenario on costs, but a distributed control strategy for individual car was not presented. The authors in [13] presented another approach to the lane departure problem. They used tools from network theory to represent a road with arcs and nodes. The network representation of a highway in their work has potential in modelling traffic in road systems. However, their paper does not deal explicitly with the lane change effect on the road capacity.

Intelligent vehicles are expected to be able to detect lane directions, sense objects or pedestrians and transmit to vehicular network for the prevention of impending collisions, or warn drivers of lane departure [14],[15]. Therefore, the transmission of lane departure warning over the vehicular network is a crucial element for developing intelligent vehicles. Lane departure warning system based on machine vision algorithm is developed by taking video from cameras mounted on the intelligent vehicles. There are many research works on this issue in recent years [16]. These works generally used different strategies aimed at certain kinds of surroundings and road conditions at different times of day. While this paper proposed software base method for transmission of lane departure warning system under various lighting conditions.

Most of the lane detection algorithms are edge-based and relied on thresholding of the image intensity. The intensity information is utilized to detect potential lane edges, followed by a perceptual grouping of the edge points to detect the lane markers of interest. In many road scenes, it isn't possible to select a threshold which eliminates noise edges without eliminating the lane edge points of interest under various light conditions [17].

Seonyoung et al., implemented the Lane detection algorithm based on hardware using optimized Hough Transform circuit architecture. In the paper the authors made the circuit small by removing the operations by sharing operators and also reduced the cycle time [1]. The lane detection methods used in [2], [3] based on thresholding and Hough transform under invariable light condition. While in this paper, the image enhancement process provided the platform to obtain an accurate segmented road lane image with minimum or null noise effect. This approach is capable in detecting and tracking road lane under various light conditions with straight or curve and shadow conditions. A software based lane detection and transmission system is proposed to reduce the hardware cost and effectively transmit real-time video among the vehicles.

Various Traffic Circumstances

The intended application of the lane detection system required to evaluate the type of conditions that are expected to be encountered in this approach. During traveling road lane markings give different illumination at the time of day, night and inside the tunnel. Roads can be marked by well-defined solid lines, segmented lines, circular reflectors, physical barriers, or even nothing at all. The road surface can be comprised of light or dark pavements or combinations. An example of the variety of road conditions is presented in Figure 1. Some roads are relatively simple scenes with both solid lines and dashed lane markings. Lane position in such scene can be considered relatively easy because of the clearly defined markings and uniform road texture. However, other complex scenes in which the road surface varies, and markings consist of circular reflectors as well as solid lines. The lane detection would not be an easy task. Furthermore, shadowing obscuring road markings makes the edge detection phase more complex. Along with the various types of markings and shadowing, day light, vehicle beam light at night and tunnel dim light can have a great impact on the visibility of the road surface as shown in fig. 1. All these circumstances must be efficiently handled in order to achieve an accurate vision system.

Fig. 1 Road Scenes in Various Circumstances

Method and System

In Real time lane departure transmission systems visual information is used to monitor surrounding, identify road lanes, warning illegal activity and determining the cause on accidents. Generally, for systems relaying on Lane marking segmentation, detection and transformation between vehicles is always a complicated problem. Most of the time these systems could not detect the poor quality lane markings due to weather, complexity under various light conditions and shadows effects are also some unfavourable conditions for image transmitting. Since the importance of these systems is to maintain safety and security using camera.

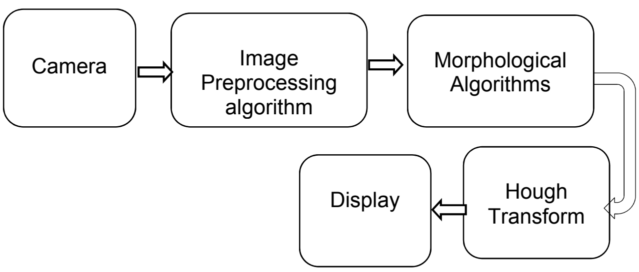


Fig. 2 Block diagram of the transmitter system

The proposed software base method is developed to transmit the real time image among vehicles as shown in fig. 2. The Image information is processed and then transmitted in order to increase safety of the road. In this method the image is captured by camera from the crossover above the road. Before sending to the vehicular network the images are pre-processed to obtain accurate transmission results. During the processing the images are compressed and segmented by generation and binarization, morphological opening and closing operations to remove the enhanced image. Hough Transform method is applied to the enhanced images for departure the lane direction and transmitted over the network for real time implementation.

Simulation Model

The simulation model shows in Figure 3 deals with all phenomena that are introduced in real time lane departure warning system for vehicular network.

Camera Position

The camera is tilted towards the ground at 45 degree, so that the camera only captured images of the road. The downward tilt of 45 degree is known as the Bird's-Eye view mapping, which reduced the processing complexity and improves the performance of the system. The frame work of the processing unit is realized using MATLAB simulation software.

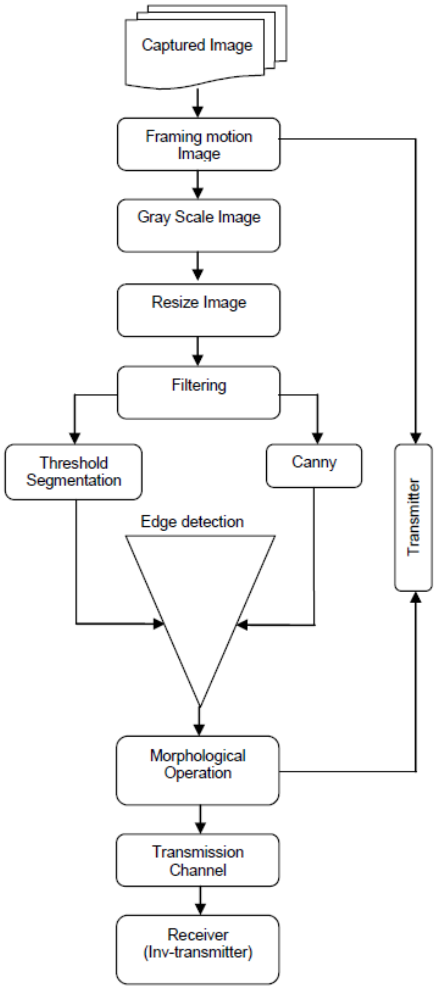


Fig. 3 Simulation flow chart for Real-Time Lane departure warning system

Colour to Gray image conversion

To retain the color information as well as to segment the road lane boundaries using the color information, edge detection becomes difficult and consequently effects the processing time. Therefore, to minimize the processing time color image were converted into grayscale. This function transformed a 24-bit, three-channel, color image to an 8-bit, single channel grayscale image. The function formed weighted sum of the Red component of the pixel value ×

0.2989 + Green component of the pixel value × 0.5870 + Blue component for the pixel value × 0.1140 and the output is the gray scale value for the corresponding pixel.

Sum weighted= 0.2989× R+0.5870 ×G+0.1140×B

Scaling image

The 2D image is scaled in to m by n matrix. The scale of the matrix is determined by the resolution of the image. Thus 256×256 resolution of the image is represented as follows

$$0<x<255 \ \& \ 0<y<255$$

Where x and y are function of 'f' which are pixels.

$$f[xy] = \begin{bmatrix} x_0y_0 & x_1y_0 \dots\dots & x_{254}y_0 \\ x_0y_1 & x_1y_1 \dots\dots & x_{254}y_1 \\ x_0y_{254} & x_1y_{254} \dots\dots & x_{254}y_{254} \end{bmatrix}$$

Median Filter

Median filter is used to remove salt and paper noise present in the image by padding at the edge of the road image. It is more difficult to detect the lane markings in the night and tunnel road surface, as the illumination condition is changed largely within the night and tunnel region. These changed would cause loss of feature information, false color tone, and shape distortion of objects, thus the lane marking filter used previously is required to be improved for this complex condition. The matrix of the median filter 15 by 15 is used to filter the salt and paper noise in the image.

Threshold segmentation

The threshold value is obtained by analyzing the image histogram of the gray scale image. The value obtained by taking the average of the threshold values in the histogram image as shown in fig. 4.

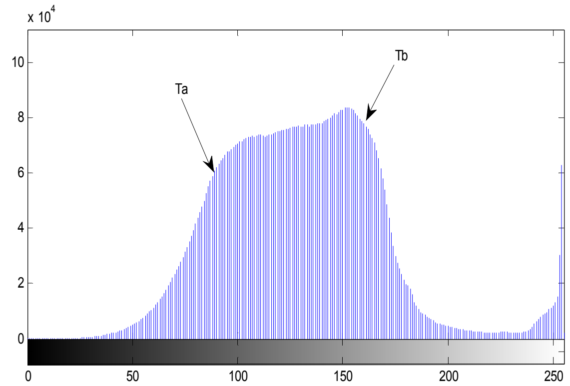


Fig. 4 Histogram of gray scale image

$$T= T_a+T_b \ ; \ T=80+160 =120$$

The threshold value is computed with respect to the estimated threshold value. If the intensity of the pixel is less then T, the pixel is gathered to a group G1. If the pixel intensity greater then T, the pixel is gathered to group G2. By taking the average intensity of the individual group a new uniform intensity value is assigned μ1 and μ2. The iteration is continued till the accurate values of μ1 and μ2 are obtained. The new threshold value is calculated by taking the average of the uniform intensity values of μ1 and μ2 as shown below

$$T_0= ((\mu_1+ \mu_2))/2$$

where μ1 and μ2 are the new values of G1 and G2.

The image segmentation depends on the present threshold value of T_0 as shown in fig. 4. If the intensity value greater the T_0, the image is assigns 1 and if the intensity value less the T_0, the image is assigned 0.

Edge Detection

The points and lines form the threshold segmented image was vital, therefore, used a canny image segmentation operator where the operator found the edge by analyzing the local maxima of the gradient of f(x,y) . The gradient was calculated using derivative of the Median filter. The filter used two parameters to detect strong and weak edges, and includes weak edges in the output if only they are interconnected to other strong edges. Therefore, this method is likely to detect true weak edges.

The gradient of the 2-D function, *f(x,y)* was calculated using the vector,

$$\nabla^2 f(x,y) = \begin{vmatrix} G_x \\ G_y \end{vmatrix} = \begin{vmatrix} \frac{\delta^2 f}{\delta x^2} \\ \frac{\delta^2 f}{\delta y^2} \end{vmatrix}$$

The magnitude of gradient operator is obtained as

$$\nabla^2 f(x,y) = mag(\nabla f) = \left[\left(\frac{\delta^2 f}{\delta x^2}\right)^2 + \left(\frac{\delta^2 f}{\delta y^2}\right)^2 \right]^{\frac{1}{2}}$$

The angle of the gradient operator is obtained as

$$\propto (x,y) = \tan^{-1} \left(\frac{\frac{\delta^2 f}{\delta x^2}}{\frac{\delta^2 f}{\delta y^2}} \right)$$

After obtaining the strength and the direction of the point using the gradient operator gives rise to ridges in the gradient magnitude image. The algorithm then tracks along top of these ridges and sets to zero all pixels that are not actually on the ridge top so as to give a thin line in the output , this process is called as non maximal suppression. Then the ridge pixels are then threshold using two thresholds, T1 and T2 withT1 < T2. Ridge pixel with value greater than T2 are strong pixels and pixels in between T1 and T2 are weak pixels, and then the edge linking is subsidized by incorporating the weak pixels.

Morphological Operations

After canny edge detection Morphological operation is applied to remove the external particles in the image, as they produced inaccurate results. The Morphological operation initially separate the closed rectangular objects form the open rectangular objects by adding pixels only to the closed rectangular objects. Thus, the objects with closed rectangular shape have higher threshold and objects with open rectangular shape have lower threshold. Eroding remove the objects with lower threshold, while leave the objects having high threshold. Thus as result the segmented image only have the required road lane.

Hough Transform

The Hough transform (HT), transforms between the Cartesian space and a parameter space in which a straight line (or other boundary formulation) can be defined. Let's consider (xi, yi) points in a road lane image, where all straight lines passing through that point satisfy the following equation for varying values of line slope and intercept (m,c) as shown in fig. 5.

$$y_i = mx_i + c$$

To reverse variables the above equation becomes:

$$c = y_i - mx_i$$

Which describe a straight line on a graph of *c* against *m* as shown in fig. 6.

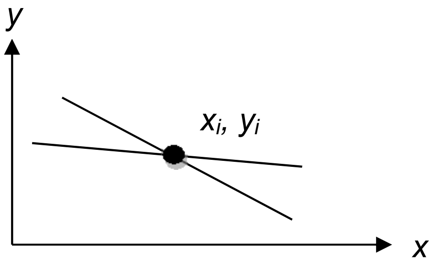


Fig.5 Lines through a point in the Cartesian domain

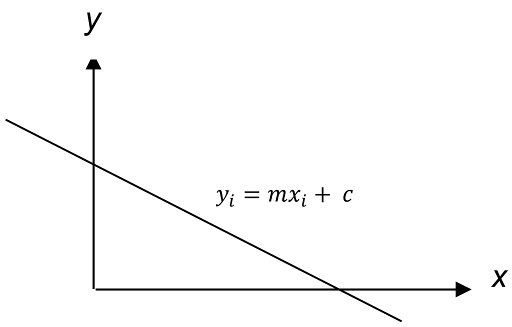


Fig.6 The (*m,c*) domain.

At this point, each different line through the point (xi, yi) corresponds to one of the points on the line in the (m, c) space.

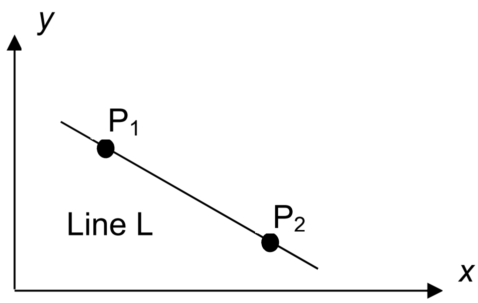


Fig. 7 Points on the same line.

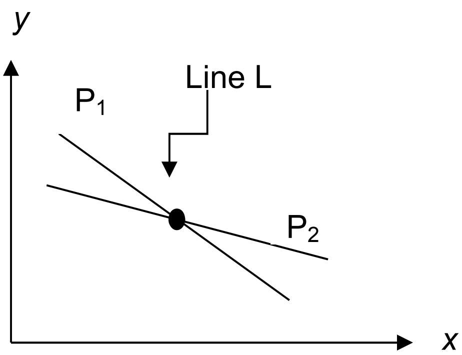


Fig. 8 The mapping of P1 and P2 from Cartesian space to the (*m*,*c*) space.

Considering two pixels P1 and P2 lied on the same line in the (x, y) space. Each pixel represented all the possible lines by a single line in the (m,c) space. Thus a line in the (x, y) space passes through the both pixels must lie on the intersection of the two lines in the (m,c) space, as shown in fig. 7 and fig. 8.

The above algorithm for detecting Line in Images as summarized as follows.

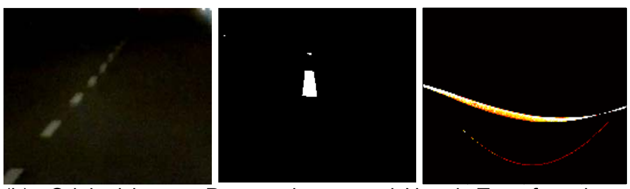
1. Find all the edge points in the image using Canny edge detection scheme.
2. Quantize the (*m,c*) space into a two-dimensional matrix H with appropriate quantization levels.
3. Initialize the matrix H to zero.
4. Each element of H matrix, H $(m_i,$ c_i $)$, which is found to correspond to an edge point is incremented by 1. The result is a histogram showing the frequency of edge points corresponding to certain (*m,c*) values
5. The histogram H is threshold where only the large valued elements are taken. These elements correspond to lines in the original image.

The conversions at the receiver side are vice-versa to described transmitter side. Only the image data interpolation in dependence on used sampling format is added as the last process of analysis.

Result and Discussion

In the developed Lane departure warning system, the road images were taken under the normal day light has very minor effect on the contrast and the intensity of the image. Since the day light is obtained directly from the sun the effect of the shadow of any object interfering with the road image contrast is minor. Hence the accuracy of processing the image for the standard threshold value is high. Total of 20 road images under the normal day light are processed. As result an accurate Hough transform graph and Hough transform peak values for 17 road images are obtained. The remaining 3 road images had a minor variation in the Hough transform graph and Hough transform peak values as shown in fig. 9(a).

(a) Original image, Process image and Hough Transform image under Day light



(b) Original image, Process image and Hough Transform image under Night beam light

(c) Original image, Process image and Hough Transform image under tunnel dim light

Fig. 9 Road images under various light conditions using Hough transform.

The road images taken in the night under the vehicle beam light has a great impact on the contrast and the intensity of the road image. The results obtained at the night time under the beam light of the vehicle undergo difficulties of segregating the intensity of the different lights provided by the street lamp and the vehicle beam. Another problem occurs due to the oncoming vehicle beam light, which blurs the road image. The results obtained from the processed 20 road images of different location of the road. An accurate Hough transform graph and Hough transform peak values for 12 road images are obtained. The remaining 8 road images showed poor accuracy as shown in fig. 9(b).

The road images captured in the tunnel under the tunnel dim light has comparing less effect on the contrast and intensity of the image compare to the road images taken in the night under the beam light of the vehicle. The images under tunnel had a draw back in processing, in which some of the line segments were considered as non-lone segments due to the low contrast of light. Another main issue raised while leaving the tunnel and entering normal daylight where the light of the sun is exposed suddenly to the captured image which make the image blur and produces faults The results obtained from the road images under the tunnel dim light provide a fairly accurate Hough transform graph and a Hough transform peak value results as shown in fig. 9(c).

The real time processing of the Lane departure system was performed by applying the image processing algorithm on the real time video of the road. The process was done for day time under normal day light, night time under vehicle beam light and in tunnel under the tunnel dims light which is shown in fig. 10. The algorithms are performed parallel to each frame of the video. The video was captured at the rate of 29.5 frames per second. But in processing though simulation software only 1.5 frames are processed per second which is about 5% of the frames which is processed with respect to the real time video as show in fig. 10.

The results obtained for the Real time Lane departure warning system was obtained after doing a trial tests for real time videos of generally 5 minutes under different conditions and environment. It can be observed that the results obtained for the normal day time videos and the results obtained for the tunnel videos under the tunnel dim light are highly accurate and contains an accuracy of a minimum of 75%.

The results obtained for the road videos in the night under the vehicle beam light gave an average performance and provided mid-range accuracy. Though the accuracy of the results obtained in normal day light and results obtained for the tunnel road images under the tunnel dim light have a large difference in the level of accuracy with respect to the results obtained in the night under the vehicle beam light the system in general contains an accuracy of 71%.

Table1. Summary of the System under Various Light condition

Category	Results		Overall Result	Results %age
	Succeed	Failed		
Normal day light	17	3	17/20	85%
Night under the vehicle beam light	12	8	12/20	60%
Tunnel dim light	16	4	16/20	80%
General system performance	45	15	45/60	75%

The accuracy of the system could have been improved if a high resolution camera was used and placed outside the vehicle. The accuracy of the real time video is poor compare to the accuracy of the still images is since the video was taken from inside the vehicle which caused to have more interference and external factors to eliminate in the processing unit. The table 1 contains the summary of the results obtained for the Lane departure warning system for normal day light, at night under the vehicle beam light; in tunnel under the tunnel dim light and general system performance. The table 2 contains the performance summary of the real time frames.

Table2. Performance summary of the system for real time processing

Category	Results		Overall Result (Frames)	Percentage of Results (Frames)
	Succeed Results (Frames)	Failed Results (Frames)		
Normal day light	3840	960	3840/4800	80%
Night under the vehicles beam light	2800	2000	2800/4800	60%
Under the tunnel dim light	3504	1296	3504/4800	73%
General system performance	10144	4256	10144/14400	70.4%

Fig. 10 Real-Time video transmission and lane departure system

Conclusion

In this paper, Hough transform method is used for lane departure detection system to ensure the road safety in real-time scenario. However, image segmentation for road lane departure under various light conditions is processed. Different operating system was used to detect edges of the road lane. In order to filter noise and segment the image, morphological operations were used as shown in fig. 9. The developed system performance in terms of normal day light, night under the vehicles beam light, under the tunnel dim light and under general system is useful for safety application as shown in fig. 11.

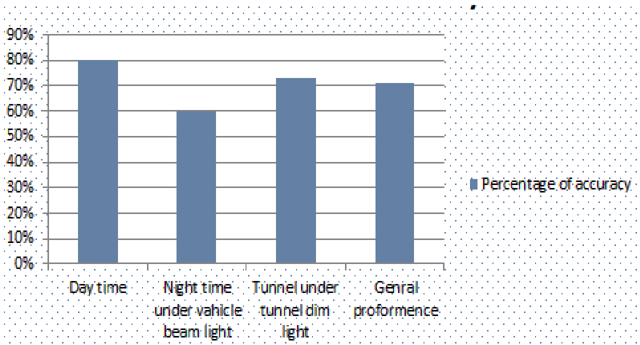


Fig. 11 Bar chart of the performance of the system for real time processing

Therefore, it is concluded that the system is able to achieve a standard requirement to provide valuable information to the driver to ensure safety.

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