Lane Departure Detection Using Edge Detection and Modified Hough Transform

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Abstract: Video sensors constitute a great innovation in the automotive sector and road safety as they contribute to the development of driver assistance systems. These video systems use image processing techniques to inform drivers of impending dangers. One such development is the Lane Departure Warning System (LDWS) which play a key role in the prevention from accidents. The main function of this system is the detection of lane boundary lines using artificial vision. In this project, we present a feature-based method for lane detection. We simplify the process of edge detection by using a horizontal differencing filter. The detected edge points are grouped into lines with a modified Hough transform.

Key words: Lane detection, region of interest, edge detection, line identification.

1. INTRODUCTION

Nowadays, the number of people killed in road accidents is increasing despite the presence in vehicles of safety systems, such as 3-point seat belt and airbag technology. In result, there is a social need to prevent motor vehicle accidents and analyze its main causes. For example, recently the U.S. National Highway Transportation Safety Administration (NHTSA) show that traffic accidents caused by driver negligence and unintentional lane deviations account for 43% of all traffic accidents in the United States.

Since man is always in the origin of accidents and in order to enhance road safety, automobile constructors and research centers are promoting researches to develop intelligent transportation systems (ITS) based on intelligent vehicles, which aims to support the driver in the prevention of accidents. Thanks to the use of electronic devices such as GPS and video sensors, intelligent vehicles can perceive the immediate environment and navigate autonomously in different road scenarios. Lane markings detection using video sensors is among the essential functions of an intelligent vehicle, since it has many applications of driver assistance (e.g. Lane Departure Warning and Lane Keeping Assistance).

In road-transport terminology, a lane departure warning system (LDWS) is a mechanism designed to warn the driver when the vehicle begins to move out of its lane (unless a turn signal is on in that direction) on freeways and arterial roads. These systems are designed to minimize accidents by addressing the main causes of collisions: driver error, distractions and drowsiness.

There are three types of systems:

- Systems which warn the driver if the vehicle is leaving its lane with visual, audible, and/or vibration warnings (lane departure warning, LDW).
- Systems which warn the driver and, with no response, automatically take steps to ensure the vehicle stays in its lane (lane keeping assist, LKA/LKS).
- Systems which assist in over steering, keeping the car centered in the lane, and asking the driver to take over in challenging situations (lane centering assist, LCA).

A Lane Departure Warning System (LDWS) is able to warn a drowsy, distracted or inattentive driver that they are about to leave the lane in which they are driving. Using image processing algorithms, this system should be able to locate lane markings in an input video frame, track these lines, calculate Time to Line Crossing (TLC) and issue a warning if TLC is under a threshold.

Extracting and tracking lane boundary lines are critical steps of the algorithm. Indeed, they require more processing time and present computational complexity. Hence, to perform a real-time software or hardware implementation, we should use methods with minimal computation's time

This paper is organized as follows: Section 2 describes the Literature survey. Section 3 reversible logic design. Section 4 Result and discussion. Section 5 gives the conclusion.

2. LITERATURE SURVEY

In this section, detailed literature review is done that aims to review the critical points of current works. Here the information collected about researches and innovations carried out on the related technologies have been done. This section will highlight the recent trends and innovations in the concerned technology.

Frederik Wigh [1] in (2007) investigated that video sensors constitute a great innovation in the automotive sector and road safety as they contribute to the development of driver assistance systems. These video systems use image processing techniques to inform drivers of impending dangers. One such development is the Lane Departure Warning System (LDWS) which play a key role in the prevention from accidents. The main function of this system is the detection of lane boundary lines using artificial vision. Here, we present a feature-based method for lane detection. We simplify the process of edge detection by using a horizontal differencing filter. The detected edge points are grouped into lines with a modified Hough transform.

A. Takahashi, Y. Ninomiya, M. Ohta, M. Nishida and N. Yoshikawa [2] in (2003), Many traffic accidents are caused by driver unawareness. This includes fatigue, drowsiness and distraction. In this, two systems are described that could be used to decrease the number, of accidents. In the first part, a system using long-term information to warn drivers suffering from fatigue is developed. Three different versions with different criteria are evaluated. The systems are shown to handle more than 60% of the cases correctly. The second part of this examines the possibilities of developing a warning system based on the predicted time-to-lane crossing, TLC. A basic TLC model is implemented, and evaluated. For short time periods before lane crossing this may offer adequate accuracy.

Ajit Danti, Jyoti .Y. Kulkarni, P.S.Hiremath [3] in (2013), Lane detection is a challenging problem. It has attracted the attention of the computer vision community for several decades. Essentially, lane detection is a multi feature detection problem that has become a real challenge for computer vision and machine learning techniques. Although many machine learning methods are used for lane detection, they are mainly used for classification rather than feature design. But modern machine learning methods can be used to identify the features that are rich in recognition and have achieved success in feature detection tests. However, these methods have not been fully implemented in the efficiency and accuracy of lane detection. In this paper, we propose a new method to solve it. We introduce a new method of pre processing and ROI selection. The main goal is to use the HSV colour transformation to extract the white features and add preliminary edge feature detection in the pre-processing stage and then select ROI on the basis of the proposed pre-processing. This new pre-processing method is used to detect the lane. By using the standard KITTI road database to evaluate the proposed method, the results obtained are superior to the existing pre-processing and ROI selection techniques.

Y. Wang, E. K. Teoh and D. Shen [4] in (2004), Traffic conditions in Indian urban and sub urban roads are in many ways not ideal for driving. This is due to faded and unmaintained lane markings. Therefore driving sometimes becomes difficult. Due to inappropriate markings of the roads, it is difficult to track the lane marking using conventional lane marking algorithms. Therefore the issue of Lane tracking with road boundary detection and other vehicle tracking for Indian road conditions is addressed here. The technique is based on modified road boundary detection which first segments the road area based on color segmentation and Hough transform is applied to find out the near vertical lines. Even in the absence of prominent lanes in the road, the segmentation line itself acts as boundary line. Further optical flow based vehicle detection is integrated with the system. When compared with conventional Hough transform based lane detection this technique is proven to be more efficient in terms of accuracy. The method is tested with Open CV under real time environment with Live Video frames. Results show accurate detection of road boundary, lanes and other vehicles under different road textures and varying intensity conditions.

Heechul Jung, Junggon Min and Junmo Kim [5] in (2013), A B-Snake based lane detection and tracking algorithm without any camera's parameters. Compared with other lane models, the B-Snake based lane model is able to describe a wider range of lane structures since B-Spline can form any arbitrary shape by a set of control points. The problems of detecting both sides of lane markings (or boundaries) have been merged here as the problem of detecting the mid-line of the lane, by using the knowledge of the perspective parallel lines. Furthermore, a robust algorithm, called CHEVP algorithm, is presented for providing a good initial position for the B-Snake. Also, a minimum error method by Minimum Mean Square Error (MMSE) is proposed to determine the control points of the B-Snake model by the overall image forces on two sides of lane. Experimental results show that the proposed method is robust against noise, shadows, and illumination variations in the captured road images. It is also applicable to the marked and the unmarked roads, as well as the dash and the solid paint line roads.

D. Katz, T. Lukasiak, R. Gentille [6] in (2006), we propose an efficient lane detection algorithm for lane departure detection; this algorithm is suitable for low computing power systems like automobile black boxes. First, we extract candidate points, which are support points, to extract hypotheses as two lines. In this step, Haar-like features are used, and this enables us to use an integral image to remove computational redundancy. Second, our algorithm verifies the hypothesis using defined rules. These rules are based on the assumption that the camera is installed at the centre of the vehicle. Finally, if a lane is detected, then a lane departure detection step is performed. As a result, our algorithm has achieved 90.16% detection rate; the processing time is approximately 0.12 milliseconds per frame without any parallel computing.

Xiangjing An, E. Shang, J. Song, and Hangen [7] in (2013), A camera-based lane departure warning system is implemented on a field programmable gate array (FPGA) device. The system is used as a driver assistance system, which effectively prevents accidents given that it is endowed with the advantages of FPGA technology, including high performance for digital image processing applications, compactness, and low cost. The main contributions of this work are threefold.

(1) An improved vanishing point-based steerable filter is introduced and implemented on an FPGA device. Using the vanishing point to guide the orientation at each pixel, this algorithm works well in complex environments.

(2) An improved vanishing point-based parallel Hough transform is proposed. Unlike the traditional Hough transform, our improved version moves the coordinate origin to the estimated vanishing point to reduce storage requirements and enhance detection capability.

(3) A prototype based on the FPGA is developed. With improvements in the vanishing point-based steerable filter and vanishing point-based parallel Hough transform, the prototype can be used in complex weather and lighting conditions. Experiments conducted on an evaluation platform and on actual roads illustrate the effective performance of the proposed system.

Xiangjing An, E. Shang, J. Song [8] in (2013), A comprehensive survey of thinning methodologies is presented. A wide range of thinning algorithms, including iterative deletion of pixels and non pixel based methods, is covered. Skeletonization algorithms based on medial axis and other distance transforms are not considered. An overview of the iterative thinning process and the pixel-deletion criteria needed to preserve the connectivity of the image pattern is given first. Thinning algorithms are then considered in terms of these criteria and their modes of operation. Non pixel based methods that usually produce a centre line of the pattern directly in one pass without examining all the individual pixels are discussed. The algorithms are considered in great detail and scope, and the relationships among them are explored.

Gurjyot Kaur , Amit Chhabra [9] in(2015), With the increase in advent of intelligent vehicle technology, LDWS technique is actively developing to provide assistance to drivers in generating warning signal in case of lane departure. In this paper, the input image is divided into four regions of interest. Then the CLAHE is applied on the given ROI for better image contrast and removal of noise using gradient filter. Improved Hough Transform is applied on the given image for the detection of curved and straight lanes. After detecting the lanes, they are coloured with green color so that they are clearly visible. The proposed algorithm is analysed based on the parameters like Accuracy, BER, Fmeasure, and Sensitivity. The analysis shows that this algorithm provides efficient and effective performance compared to the existing algorithm.

3. PROPOSED WORK

Lane Departure Warning System:

The vision based Lane Departure Warning System (LDWS) is a effective way to prevent Single Vehicle Road Departure accident. In practice, a variety of complex noise make it very difficult to detect lanes fast and accurately, so to establish a set of image processing method which can give results fast and accurately in the non-ideal conditions is the primary work. In this paper, a lane detection method for Lane Departure Warning System is proposed. The Canny algorithm is determined as the edge detection method according to the experiment comparison, and Hough transform is selected as the efficient way to detect the beeline. To meet the real-time requirement, the region of interest (ROI) is defined to reduce noise for rising accurately, and to enhance the processing speed. At last, experiment results indicate that this lane detection method can extract lane information from road images acquired efficiently and accurately.

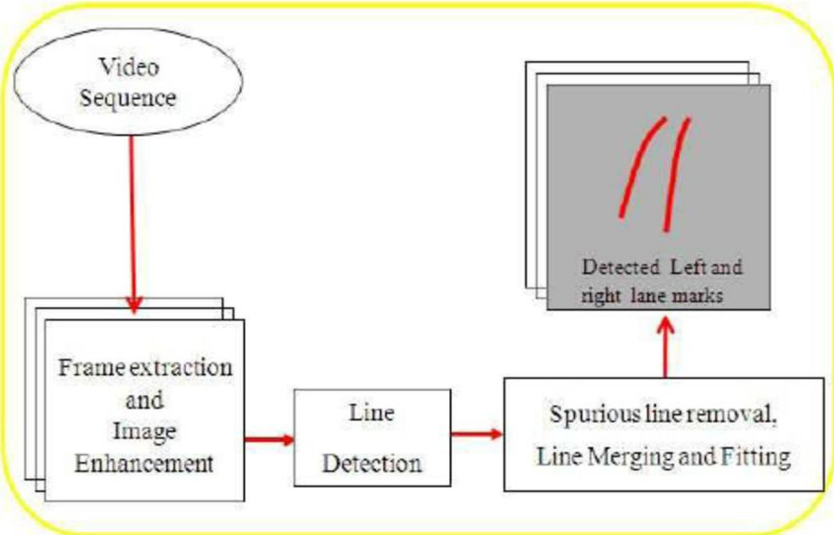

Figure1: Block Diagram of Lane Departure Waning System

Developing a vision based, efficient and automatic lane detection system from a moving vehicle is a challenging task mainly due to poor quality of lane markings, occlusion created by traffic, complex road geometry and nevertheless, the non-existence of unique models. The focus of this paper is to detect line or curve like segments from a video image taken from moving vehicle and merge them to detect road lane marks. In this work, we propose a method of applying weighted regression to fit a curve in place of traditional line grouping and fitting curve separately. The proposed vision based solution is simple but computationally efficient and hence works in real time on the image sequence captured by camera mounted in the vehicle.

The application of Computer Vision systems has boosted the advances in automation systems in various domains such as transport, surveillance, medical and retail. For example, lane mark detection, on-road obstacle detection, traffic monitoring system and their integrations for automatic vehicle guidance and safety systems are some of the demanding applications in the field of transport. In the recent years most of the on road accidents and mishaps are caused due to speeding and rash driving. As the traffic ahead is not known, the chance of accident is high. With the new generation of large number of heavy vehicles on the roads and most drivers changing lanes as often as possible, thence the rise of accident rate. Thus, there is a need of driver aid system to perform emergency alarm generation to increase the safety of automobiles. To avoid a vehicles straying out of lane, interest in lane departure warning and tracking systems has increased a lot among the research community as well as the product groups. These systems also have widespread applications in intelligent transport systems and robotics Researchers have made some attempts in vision based lane detection and road boundary detection to warn or assist in vehicle guidance. However, it is clear that such systems are mainly affected by shadows, bad weather such as fog, rain, multiple source of lights, instability in camera view and by varied illumination (e.g. change of light source from broad day to evening and late night). As the field of view of the camera has to deal with road perspective, the points that are close to the top of the image has a bigger uncertainty than the bottom ones. In many cases the uneven curvature at the far end makes it difficult to estimate lane marks properly and line detection and their merging works poorly under such cases.

In the view of above challenges and industrial demand, we developed a feature driven methodology for real-time lane detection for automotive vehicles. The block diagram explains the system overview of the method for Lane detection. The basic input is a video file taken from camera mounted on a moving vehicle.

Automatic lane detection can be categorized into lane-region detection, model driven and feature driven approaches. In lane-region detection, representation by colour and texture features for road and/or non-road segments by using stochastic pattern recognition techniques followed by segmentation are popular. The authors have tried to apply colour segmentation and threshold on enhanced colour channels to detect lane marks. However, colour consistency is still very challenging due to variation in illuminations and road visibility. The aim in model driven approaches is to match a deformable template (snakes and splines) through scene characteristic to model road segments. Model driven approaches provides good results in lane detection application but they require heavy computation. Feature driven approaches (local feature extraction, supervised methods for classification of lane marks) faces many challenges such as noise effect, blur and irrelevant feature structure but they do have flexibility of local and global feature representation for near and far end curved lane marks and hence seems promising in lane mark analysis and tracking.

In the view of above challenges and industrial demand, we developed a feature driven methodology for real-time lane detection for automotive vehicles. The block diagram explains the system overview of the method for Lane detection. The basic input is a video file taken from camera mounted on a moving vehicle. The flow of the method is depicted in this diagram. The major components in this approach includes video capture and frame extraction, line/curve like mark detection, spurious segment removal, line merging and fitting curves.

Principle of Lane Departure Detection

A lane detection system used behind the lane departure warning system uses the principle of Hough transform and Canny edge detector to detect lane lines from real time camera images fed from the front-end camera of the automobile. A basic flowchart of how a lane detection algorithm works to help lane departure warning is shown in the figures.

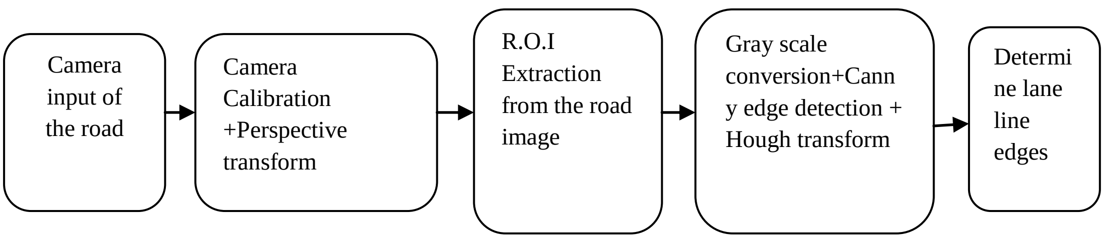

Figure 2: Lane Departure Algorithm

Lane Mark Detections:

Moreover, varied colour mark, uneven structure at far end perspective camera view, simple pixel features, colour value or road texture are not prominent for lane mark candidate features. Local gradient and edge component are more appropriate for lane mark hypothesis generation. A computationally faster algorithm for line like structure detection by gradient information extraction and randomized Hough transform is proposed. It performs well when the lanes are straight, but not quite suitable for detecting curving lanes. Other such similar feature like canny edge, steerable filters are attempted for lane mark estimation and tracking. They have tried simple gray and colour pixel value with supervised classifiers (ANN, SVM, Naive Bayes). In these works, the detected line segments are assembled into lane structures using merging and grouping them according to their spatial position and orientation. Least square fit, Random Sample Consensus(RANSAC), Hyper parabola or B-spline fitting is the next step to estimate the probable position of aggregated lane in image frame. Inverse Perspective Mapping (IPM) along with particle filtering (for detecting lane structure with highest voting) is one of well suited techniques used for lane detection. This technique failed to detect lane, when there are disconnected lines at the initial stage of the image. A robust lane detection-and-tracking algorithm is reported to have good performance in dealing with challenging scenarios such as lane curvature, lane changes and splitting lanes in. In this method a major case of miss detection is due to fast lane changes.

Here, we describe our proposed method of detecting lanes, by extracting small line like structures of the lane using Sobel gradient operator and canny edge detection, probabilistic Hough Transform for line segment detection, and then clustering the line segments. We used clustering method to group the line segments with their slope and Y-intercept in two different stages:

(i) Clustering with slopes of line segments as input and
(ii) Clustering again with Y-intercepts of the grouped lines from previous step. This is mainly to get distinct distance between line segments with respect to their angle and positions separately, as they are values of different scales (which may hamper the distance computation for proper clustering). Secondly, this two stage separation helps us to compute weight according to Y-intercepts for each lines in their group and apply heteroscedastic regression to fit lane marks (line or curve fitting).

Most of the works in the literature, merging of the line segments is done by simple threshold or clustering on similar slope and position followed by curve fitting. In this work, we combine the line grouping and curve fitting in a single step in order to improve computational efficiency. This is carried out by the use of weighted least square regression. Figure 2 shows the flow of the proposed solution. The dotted line in this diagram shows the two stage clustering process, while the solid line shows the proposed method of weighted regression based on Y-intercepts. The stepwise output for an image frame as shown in figure.

The input image is smoothed by Gaussian smoothening method followed by gradient computation and edge detection. We applied probabilistic Hough transform on the detected edges to identify the line segments. In standard Hough transform the lines are detected by putting the edge points into similar rho (ρ) and theta (θ) (parameter of the line equation) values. The detected line segments are shown in red lines in the second block. We applied Probabilistic Hough transform to achieve computational advantages as compared to standard Hough transform with negligible performance degradation. As the name suggests, probabilistic Hough transform detect lines from few of the randomly selected edge points, thus helps in faster computation than standard Hough transform technique

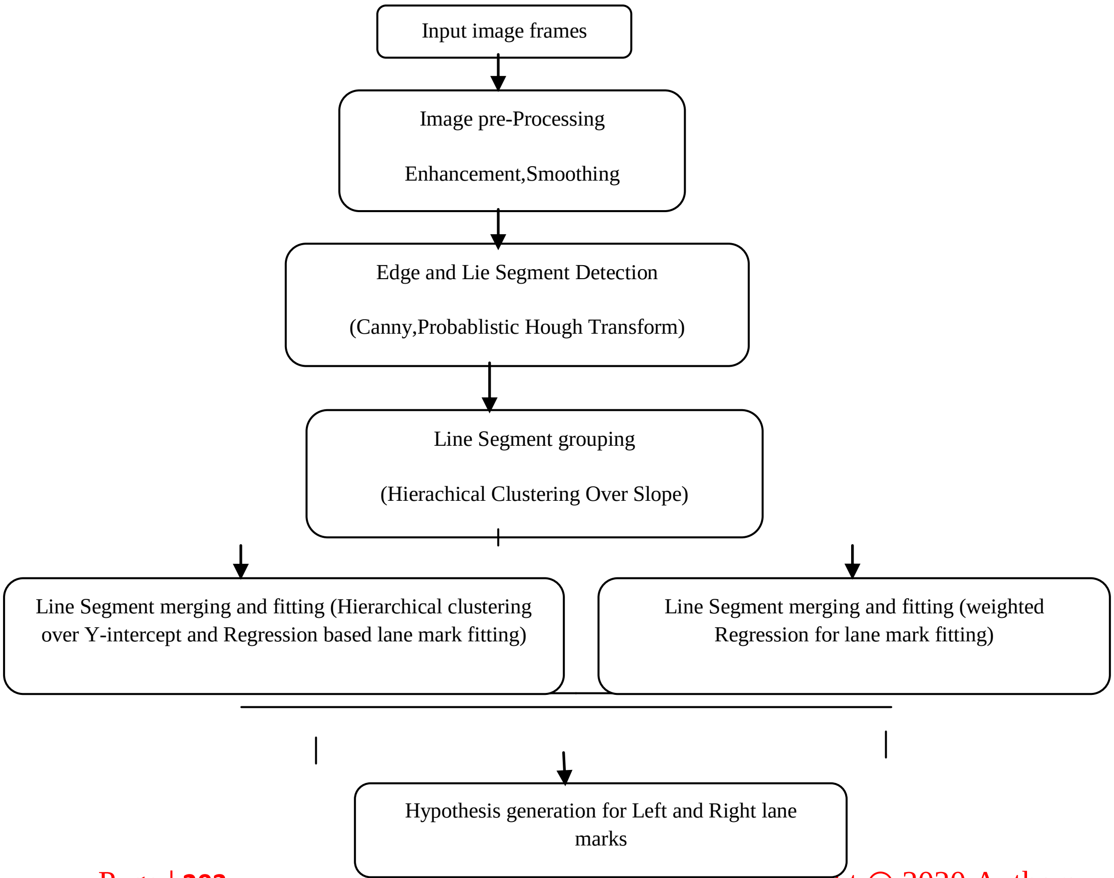

Figure 3: Flowchart for Lane Mark Detections

Our Approach:

We aim to develop a robust algorithm and ensure a real-time detection, because we are interested on a real-time implementation. For this purpose, our optimizations will concern image pre-processing, edge detection and line tracking steps. As a Smoothing filter, we will use an average filter. The choice of this filter is due to its simplicity on comparison with the median filter. We aim to develop a robust algorithm and ensure a real-time detection, because we are interested on a real-time implementation. For this purpose, our optimizations will concern image pre-processing, edge detection and line tracking steps. As a Smoothing filter, we will use an average filter. The choice of this filter is due to its simplicity on comparison with the median filter.

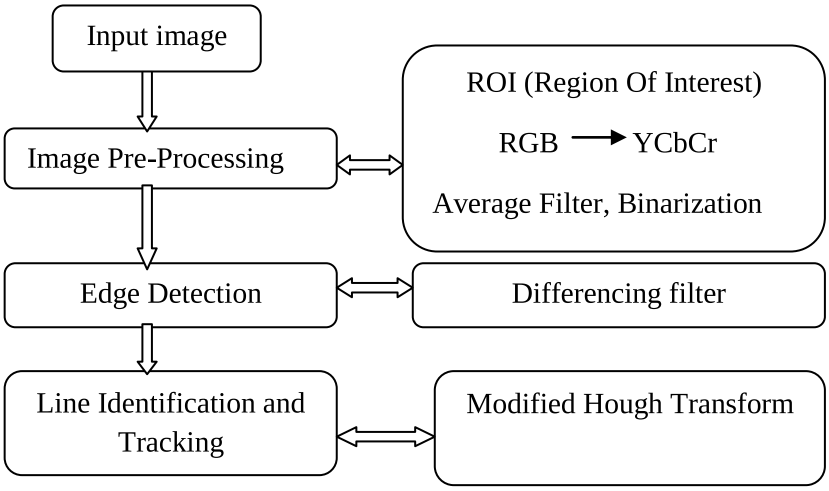

Figure 4: Proposed Method for Lane Departure Detection

This step is the most valuable one in our algorithm. Thanks to the definition of the Region of Interest (ROI) in our image, we confine the field of view in order to decrease noise edges. This procedure consists of storing in memory only the region of image that contains the relevant information (i.e. boundary's lines). We estimated this region to begin from the second third of a QVGA (320x240).

The purposes for the construction of the ROI are the reduction of processing time and the reduction of memory space required for each video frame. Moreover, we limit the number of memory access. Then, the RGB colour image is converted to an intensity image and the rest of operations are performed on intensity image. Next, we apply to the ROI of the image an average filter to reduce noise effects. Finally, we threshold the intensity image to obtain road lines. A good choice of a threshold value allows us to detect both yellow and white lane boundary lines.

Figure 5: Region of Interest

Working of LDWS

Lane departure warning employs a simple camera. The camera plus processing software used to watch how close the vehicle is to lane markings. It gives signal to driver when he is about to cross, but only if your turn signal isn't on.

How it works

The most common LDW system uses a camera location at front side of vehicle. It continuously captures a front view of the road ahead. The image is used further for digital processing. The driver supposed to centre the car between the two lines. If the car unintentionally approaches or reaches the lane marking, the driver gets a warning. If the turn signal is on, then the car gives no warning. That's lane departure warning system. The basic idea, but there are several versions of the technology available now, including ones that react and steer away from the lane edge and even proactively keep the car centered. All forms of lane departure warning employ a low-cost camera mounted in the windshield near the rear view mirror that continuously watches the striped and solid lane markings of the road ahead. It is part of the circle of safety, the three most common and useful driver assists: protecting you to the front (adaptive cruise control and forward collision warning), side (lane departure warning), and rear side (blind spot detection).

Technology has driven the cost of the three together down to less than $1,000 on many cars. Thinking about buying a car with some form of lane departure warning? Here's what you need to know.

Features of Lane Departure Detection

- As the car deviates and approaches or reaches the lane marking, the driver gets a warning: a visual alert plus either an audible tone, a vibration in the steering wheel, or a vibration in the seat. If the turn signal is on, the car assumes the driver is intentionally crossing over the lane, and there's no alert.
- In road-transport terminology, a lane departure warning system (LDWS) is a mechanism designed to warn the driver when the vehicle begins to move out of its lane (unless a turn signal is on in that direction) on freeways and arterial roads. These systems are designed to minimize accidents by addressing the main causes of collisions: driver error, distractions and drowsiness.

Goal of Lane Departure Detection

Lane departure crashes account for a significant proportion of passenger car occupant fatalities and serious injuries. Utilizing real-world data involving fatal passenger car crashes in Sweden, the characteristics of lane departure crashes were identified and the safety potential of lane departure warning (LDW) systems was quantified.

IV.RESULTS AND DISCUSSION

To evaluate the performances of the proposed methodology, we applied it in different road scenes. In figure 6, we present only results in the ROI of each tested image. Results show that we can detect both yellow and white road lines. Therefore, the tracking mode allows us to select lane boundary lines among others candidate lines which can be present in a real road image. However, the tracking mode needs to be improved, because in some cases there is a false detection of road lines specially when there is a road lane change. We added in some video frames a salt and pepper noise. Despite the presence of this noise, we can detect the corresponding lines.

Figure 6: Experimental Results

4. CONCLUSION

In this paper, we have used image processing techniques to detect lane boundary lines. The proposed method has offered good performances, but it has to be improved in order to be adapted with bad weather conditions (e.g. rain and snow) and bad light conditions (night time).

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