Video Based Lane Departure Warning System using Hough Transform

Thanda Aung, and Myo Hein Zaw

Abstract**—**Road traffic accident is one of the problems that are risking lives of people. Many lane departure crashes especially on high-way roads are due to driver's inattention or incompetence or drowsiness. Therefore a system is needed to save the considerable number of lives by warning the driver of imminent danger. Detecting and localizing lanes from a road image is an important component of many intelligent transportation systems. In fact lane detection is one of the most studied topics for intelligent transportation systems within the present decade. Many research teams around the world have been trying to improve lane detection and warning systems. For the lane detection system to become more effective, the system must be as cheap as possible. Therefore, instead of using sensors such as RADAR, most systems are being implemented with the help of video camera. The most prevalent methods involve visible-light cameras, and are based on computer vision and image processing. This paper describes implementation of a lane detection system using Hough Transform. The proposed system can detect road lane markers in a video stream and an unintended departure from the lane. The input to the system is video streams recorded by the video camera mounted on the vehicle. The input is processed by using Hough Line and Hough Transform to detect lane marks. The detected lane marks and vehicle positions are used to determine whether the vehicle stays on its lane or stays out of lane. The system will produce an alarm message to the driver for lane departures.

Keywords**—**Computer Vision, Hough Transform, image processing, lane detection, video processing

I. Introduction

AMONG the serious accidents which are happening nowadays, unintended lane departure is the leading course that is risking lives of people. A fatal collusion can occur within split second due to driver's inattention or drowsiness. At the end of a long drive back from holiday or after a stressful and tiring day at work, drivers are accidentally at risk of falling asleep for a few seconds. To reduce the increasing mortality rates due to traffic accident, a system is needed to warn the driver if the vehicle begins to drift out of its lane. Therefore many researchers and research teams are being trying to improve intelligent vehicle systems to assist the driver or to control the vehicle autonomously. Lane Detection System is one of the most studied areas among intelligent vehicle systems. The lane detection system is extraction of road lane markings and edges and estimates the position of the car within the lane. Camera based systems relying on computer vision and image processing is one of the most desirable methods used to carry out these functions.

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]. Research in several fields of traffic applications has resulted in video processing and analysis methods as video sensors become particularly important in traffic applications. Video sensors offer a relatively low installation cost with little traffic disruption during maintenance. Furthermore, they provide wide area monitoring allowing analysis of traffic flows and turning movements (important to junction design), speed measurement, multiple point vehicle counts, vehicle classification and highway state assessment (e.g. congestion or incident detection) [4].

The main objective of this paper is to implement a cost effective video based lane departure warning system. In this paper, image processing based lane departure warning system is composed with processing steps: filtering, edge detection, lane detection and departure detection. Warning to return focus to the wheel is produced after applying edges detection and Hough Transform. The remainder of the paper is arranged as follows: some recent proposed lane departure warning systems are described in Section II, Section III provides an overview of the proposed system, Section IV provides results for various experimental conditions and Section V concludes and presents directions for future work.

II. Related Work

To help preventing driver's mistakes and reduce traffic accident effectively, many Driver Assistance systems are emerging to work in harmony with human drivers. Many digital devices for driver assistant system were developed and implemented in the past decade [5]. Most of them were costly aids such as GPS navigation systems, inductive loop detectors and sensors, etc.

One of the alternatives to a vision-based approach is using a global-position system (GPS) with a geographic information system (GIS). 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 because the GPS has a limitation on the spatial and temporal resolution, and detailed information is

Thanda Aung is with the Faculty of Information and Communication Technology Department, University of Technology (Yatanarpon Cyber City), Pyin Oo Lwin, Myanmar (htunaung.thanda@gmail.com).

Myo Hein Zaw is Principal and Associate Professor, Computer University (Monywa), Monywa, Myanmar (mheinzaw@gmail.com).

often missing or not updated frequently in GIS. Therefore, it is challenging to determine the exact lane position that a vehicle is departing [6], [7].

The system proposed in [8] uses a fast vanishing point estimation method by extracting and validating the line segments from the image with a line detection algorithm. The system works in an average of 12 milliseconds for each frame with 640×480 resolution on a 2.20 GHz Intel CPU. This performance metric shows that the algorithm can be deployed on minimal hardware but still provide real-time performance.

Another system is based on color information that is developed by [9]. This lane-detection method is proposed to handle moving vehicles in the traffic scenes. The input to the system is a series of images taken from a digital camera with different distances in an urban street. Firstly an adaptive region of interest ROI is set. Based on the color information, the lane marks are then extracted to eliminate many articles that might interfere with lane-detection process. The lanes were detected using segmentation and morphological operations in restricted search area.

III. Lane Departure Warning System

Lane departure warning system is a mechanism designed to warn a driver when the vehicle begins to move out of tis 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 [10].

Lane detection is an important functionality of Lane Departure Warning System. Lane detection is a well-researched area of computer vision with applications in autonomous vehicles and driver support systems. A lane detection system must be able to pick out all manner of markings from cluttered roadways and filter them to produce a reliable estimate of the vehicle position and trajectory relative to the lane. To develop a robust lane detection system that can accommodate with a variety of different conditions, the system must be developed by integrating the lane marking detector with the lane tracking system [11].

In order for a lane detection system to be effective, it should [12]:

- detect only those image features which correspond to road markings, i.e. ignore road barriers, or other traffic
- ignore irrelevant road markings, i.e. writing on road surfaces or road markings not parallel to the vehicle's lane and
- be able to detect and track not only those markings delimiting the vehicle's immediate lane, but also adjacent lanes to allow tracking to be uninterrupted during, and after a lane change.
- A Typically, lane detection system process includes:
- smoothing
- edge detection
- line detection and
- lane detection.

Smoothing is the process of removing noise from an image by using one of the various filters [13]. 2D- FIR filter [14] is selected among other edge operators to generate a binarized edge map. Hough transform is applied to the edge map to detect lines and Hough line to detect lane boundaries.

A. Figures and Tables

Removing noise is very important because the presence of noise in the system will affect the detection of edge. Three fundamental steps performed in edge detection system are [15]:

- Image smoothing for noise reduction.
- Detection of edge points. This is a local operation that extracts from an image all points that are potential candidates to become edge points.
- Edge localization. The objective of this step is to select from the candidate edge points only the points that are true members of the set of points comprising an edge.

B. Line Detection

Lines are detected with Hough transform [16] that transforms between the Cartesian space and a parameter space in which a straight line can be defined. The advantage of Hough transform is that the pixel lying on one line need not all be contiguous. Therefore, it is very useful for detecting lines with short breaks in them due to noise or partially occluded by objects. Following steps are used for detecting lines in images [17].

- Find all the edge points in the image using any suitable edge detection scheme.
- Quantize the (m, c) space into a two-dimensional matrix H with appropriate quantization levels.
- Initialize the matrix H to zero.
- Each element of H matrix, H(mi, ci), which is found to correspond to an edge point is incremented by 1. The result is a histogram or a vote matrix showing the frequency of edge points corresponding to certain (m, c) values (i.e. points lying on a common line).
- The histogram H is thresholded where only the large valued elements are taken. These elements correspond to line in the original image.

C. Lane Detection

Lane detection phase uses the edge image, the Hough Lines [18] and the horizontal lines as input. The Hough Lines object finds Cartesian coordinates of lines that are described by rho and theta pairs. The object inputs are the theta and rho values of lines and a reference image. The object outputs the zero-based row and column positions of the intersections between the lines and two of the reference image boundary lines. The boundary lines are the left and right vertical boundaries and the top and bottom horizontal boundaries of the reference image.

D. Lane Tracking

Lane Lane tracking is processed by matching and by Kalman filter. First, the distance between the lines found in the current frame and those in the repository. Then, the best matches between the current lines and those in the repository.

If a line in the repository matches with an input line, replace it with the input one and increase the count number by one, otherwise, reduce the count number by one. The count number is then saturated.

Kalman filtering algorithm [19] works in a two-step process. In the prediction step, the filter produces estimates of the current state variables, along with their uncertainties. Once the outcome of the next measurement (necessarily corrupted with some amount of error, including random noise) is observed, these estimates are updated using a weighted average, with more weight being given to estimates with higher certainty.

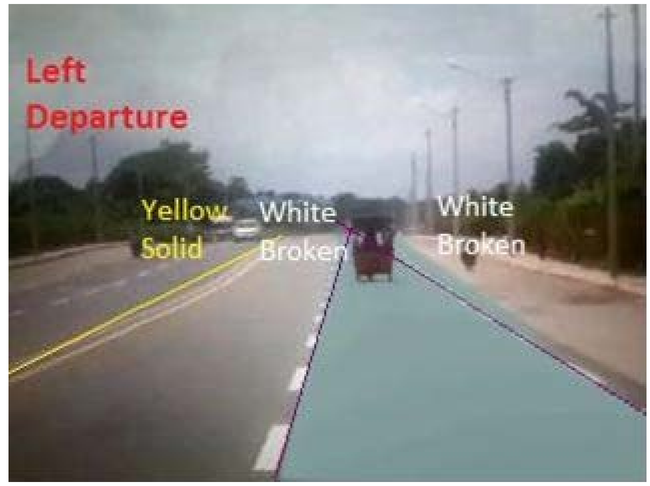
IV. Experimental Results

This paper describes a lane detection system based on image processing and computer vision techniques. Input to the system is video streams recorded by the video camera mounted on the vehicle. The input image is divided horizontally into two sub-frames. Dividing the frame is intended to reduce the processing time as only the lower part of the frame is needed to detect various types of lane marks such as solid line, dashed line, etc. Difficulty of determining lane marks on various types of road due to shadows, occlusion by other vehicles, etc. can be equalized by applying filtering techniques. 2D FIR filter is applied at the input image to remove noise and to detect edge of the lane. Filtered image is then applied with auto thresholding to convert the input grayscale image to binary image that identifies lane markers under various lighting conditions. Then finding the left and right lane markers is done by using Hough Lines and Hough Transform. This system detects lane markers by matching the current lane markers with the markers from previous video frame and by using Kalman filter. Depending on the classified lane marks and the vehicle position, the system produces a warning alarm if the vehicle moves across either of the lane markers.

TABLE I
Accuracy Result for Detection at Different Lighting Conditions

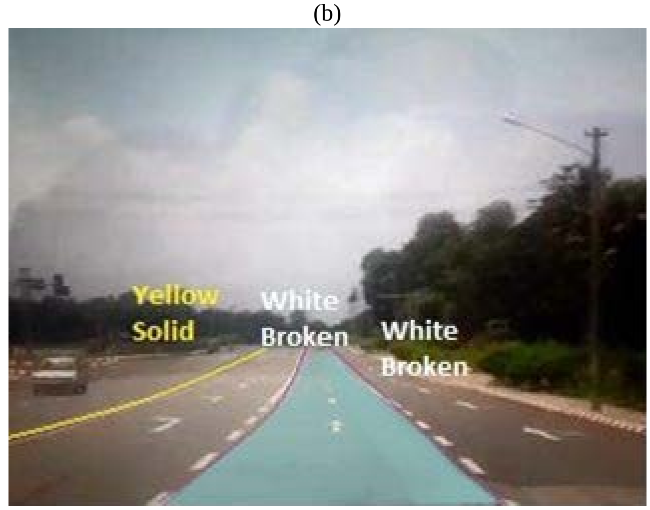
Condition		Accuracy
Straight Lane	Cloudy Condition	96.5%
	Sunny Condition	98.7%
Curved Lane	Cloudy Condition	90.4%
	Sunny Condition	94.3%

In this paper, the algorithm was implemented in a Lenovo Intel ® Core TM (i7) 2.30GHz computer using MATLAB/Simulink [20].This system is tested by using the dataset recorded from Nay Pyi Taw-Mandalay (Myanmar) high way road. The input video format type is .avi format. The input frame size is 320 by 240. The average running time of the algorithm is 10 milliseconds which is faster than former lane detection systems. The accuracy rates for detection at various lighting conditions are shown in Table 1. Some examples of detection results are shown in Fig. 1.

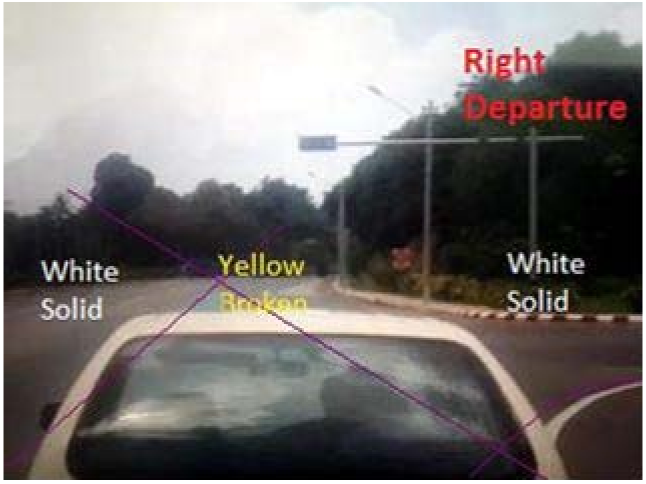


(a)

(b)



(c)



(d)

Fig. 1 Example of detection results (a) detection on straight line (b) detection on curved road (c) detection on different lane marks and (d) detection when occluding by vehicle.

V.CONCLUSIONS

This paper reported lane departure warning system based on images taken from video camera mounted on the vehicle. In this system, lower parts of the input frames out of the video sequence are first filtered using 2D FIR filter and the filtered image is performed auto thresholding operation. The detection of lane marks and lane boundaries are proposed using Hough Transform and Hough Lines. Lane tracking is processed by matching current frame with those in the repository and using Kalman filter. Lane change is detected by identifying the change in lane angels. According to the detected lane change the system detects deviation of vehicle from the lane and issues an alarm to warn the driver.

The proposed system can detect road lane markers in a video stream and an unintended departure from the lane. The system can process low quality video sequences where lane markers might be difficult to see or are hidden behind objects. In such cases, the proposed system waits for a lane marker to appear in multiple frames before it considers the marker to be valid.

The limitation of the system is its inefficient detection at poor visible conditions especially at night. Another limitation is that the input to the system is a dataset recorded from video camera. To develop a system that can be used at real-time video processing is left for future work.

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