Detection of Lane Departure using 2-D FIR and Hough Transform

Thanda Aung, Myo Hein Zaw

Abstract— **Detecting unintended departure to warn the driver is one of the most important processes to reduce the occurrence of traffic accident. Lane departure warning system implemented with the use of video camera is a solution to avoid lane departure with low installation cost and high reliability. This paper presents a vision-based lane departure detection system. 2-D FIR (two dimensional finite impulse response) filter is used to remove noise and unwanted feature or components for sufficient edge detection. The lanes are detected using Hough Transform. The system is implemented to produce departure warning based on the detected lane marks and vehicle position.**

Index Terms—**2-D FIR, computer vision, Hough Transform, image processing, lane detection.**

I. Introduction

Nowadays, mortality rates are increasing due to traffic accidents. As the population of a country becomes bigger, the amount of vehicle usage is also increasing. That raising amount of using cars leads to increase in traffic accident. Most of the traffic accidents occur on the highway roads due to driver's inattention or incompetence. 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. 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 drowsiness. To reduce the increment of 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.

There are many lane detection techniques for departure warning. Some used laser-based sensors, video sensors and GPS (Global Positioning System) data, etc. However, low spatial resolution and slow scanning speed of laser-based sensors and flaws of GPS such as not always being available when needed, vision-based sensors are becoming wide spread use. The main advantages of a video based system are its ability to capture more data with a single camera than an array of others sensors and extendibility of the system's functionality with nominal amount of code change [1].

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Moreover, the most prevalent methods used to carry out to provide information such as lane structure and the vehicle position involve camera based systems relying on computer vision and image processing.

This paper presents lane detection system for departure warning using video sensor and it is organized into five sections. The main objective of this paper is to implement a cost effective video based lane detection system that warns the driver if the vehicle drifts out from its lane. The remainder of the paper is arranged as follows: methods that are used in lane detection systems are described in Section II, Section III provides an overview of the proposed system, Section IV provides results for various experimental conditions. This paper concludes in Section V.

II. Methodology

The proposed system is developed by using the following methods.

A. *Input Data Set Creation*

Video is captured under various lighting conditions. Although the captured video sequence is short, it is recorded to contain different road segments.

B. *Pre-Processing*

To reduce the processing time of the system and to meet the system requirements, it is especially required to perform pre-processing phases: smoothing.

Image smoothing is required to reduce noise in the input data such as shadows casts from trees, building and other vehicles, bad quality lines, other markings on the road, etc. This process is necessary because removing noise is important as the presence of noise in the system can affect the detection of edge. [2]

C. *2-D FIR filter*

2-D FIR filter is used to support in edge detection. Edge detection is essential in image processing because edges represent a large portion of characteristics contained in an image. The conventional edge detectors can detect edges with abrupt change of light intensity such as step edges. The 2-D FIR edge detector is designed for the regions where light intensity changes slowly. It has the ability to differentiate the edge and to smooth the noises in a nosy image simultaneously. It is also computationally more efficient than the popular Laplacian of Gaussian method. [3]

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D. Hough Transform

The Hough transform maps points in the Cartesian image space to curves in the Hough parameter space using the equation; *rho = x*cos(theta) + y*sin(theta).*
where, *rho* denotes the distance from the origin to the line along a vector perpendicular to the line, and *theta* denotes the angle between the x-axis and this vector. This object computes the parameter space matrix, whose rows and columns correspond to the rho and theta values respectively. Peak values in this matrix represent potential straight lines in the input image. [4]

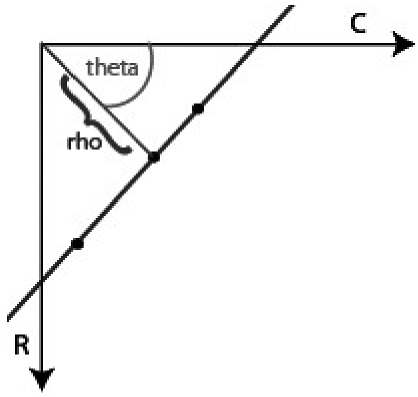

Fig.1. The algorithm of Hough Transform.

E. Lane Detection

Lane detection phase uses the edge image, the Hough Lines [5] 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.

F. Lane Tracking

At smoothing process some data may lost. Lane tracking is processed of matching by using 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. [6]

III. PROPOSED SYSTEM

This paper describes detection system for lane departure based on image processing and computer vision techniques. The system block diagram of the proposed system is as shown in Fig.2. Input to the system is video streams recorded by the video camera mounted on the vehicle. The input video is recorded from Taungnyo Road, Nay Pyi Taw, Myanmar. The proposed system perform the detection of departure as the following steps:

- getting input video file: any video file types that are supported by window media player can be processed.
- taking the lower part : the input video is split horizontally. Splitting the input frame can reduce the processing time.
- smoothing and edge detection: 2D-FIR and auto threshold methods are used for smoothing and edge detection. Fig.3 shows the results of image after applying edge detection process.
- line detection : Hough Transform and Hough Line methods are used for line detection. Fig.4 shows the result of line detection.
- lane matching and tracking : detects lane markers by matching the current lane markers with the markers from previous video frame.
- departure warning: displays of detected lane marks and produces a warning depending on the classified lane marks and the vehicle position. The system produces left departure warning message the vehicle moves across left lane markers and right departure warning message the vehicle moves across right lane markers.

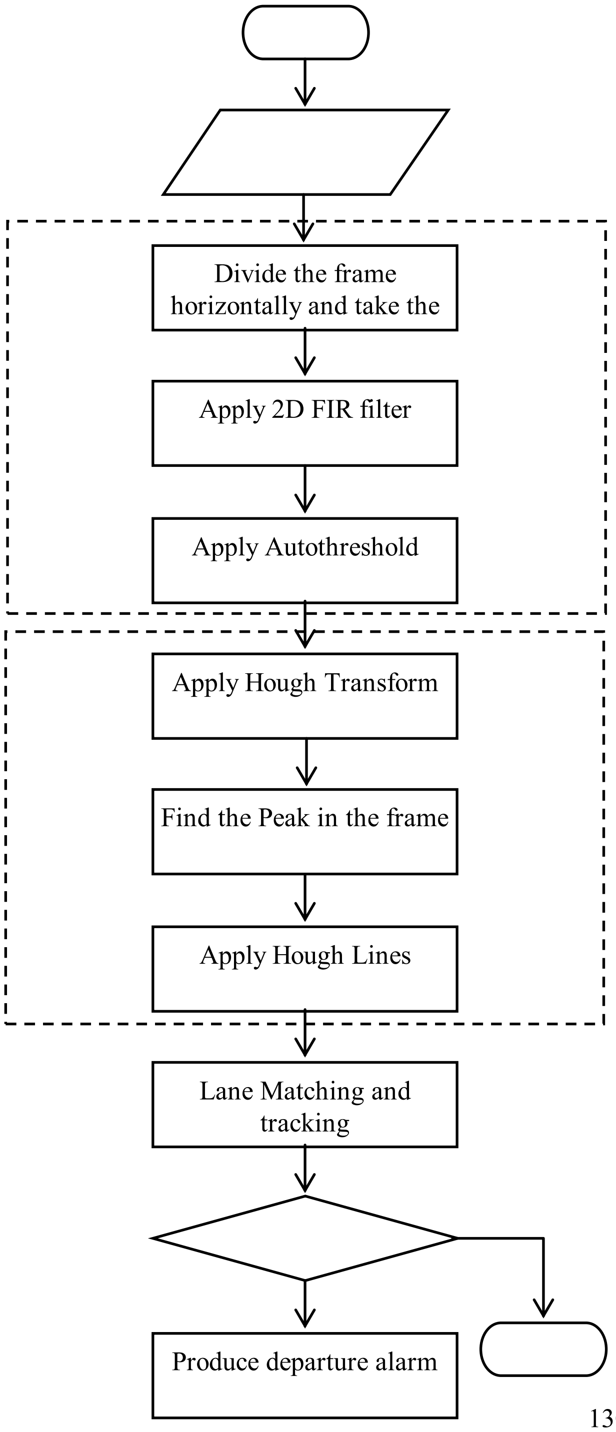

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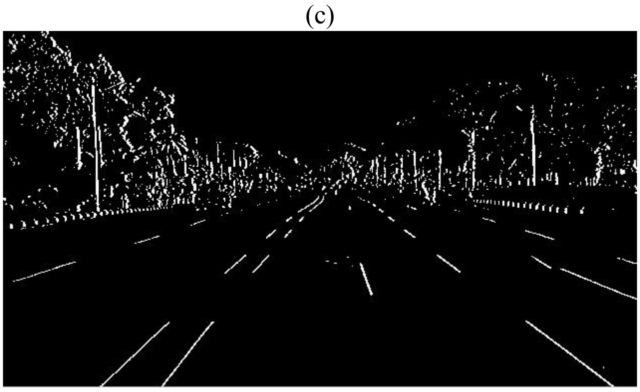
Fig.2. System block diagram of the proposed system.

(a)

(b)

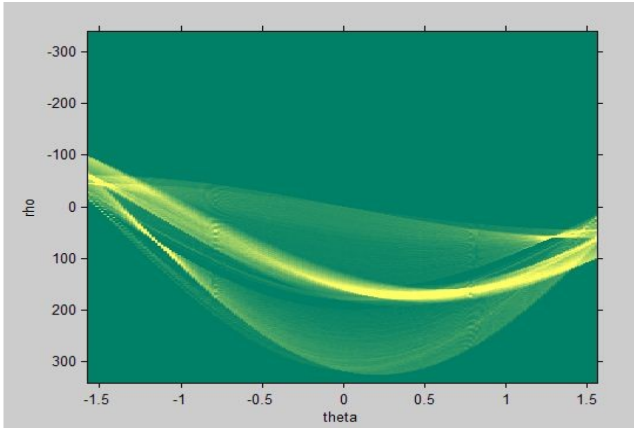
(c)



(d)

Fig.3. (a) Original image, (b) RGB to intensity image, (c) Filtered image and (d) Thresholded image.

(a)



(b)

(c)

Fig.4. (a) Original image, (b) Image applied by Hough Transform and (c) Image applied by Hough Line.

IV. Experimental Results

In this paper, the system is implemented by using a Lenovo Intel ® Core TM (i7) 2.30GHz computer using MATLAB [7]. Tested lane detection results under different lane conditions are shown in Fig.5.

According to the tested results, the system can detect any size of input video frame resolution but the ideal frame size resolution is 360x240 pixels per frame. As stated above, the system can process any type of input data format and the ideal data format is (.avi) format.

The system is implemented to reduce the processing time and average running time is 9.67 milliseconds. The accuracy rates for detection at various lighting conditions are shown in Table1.

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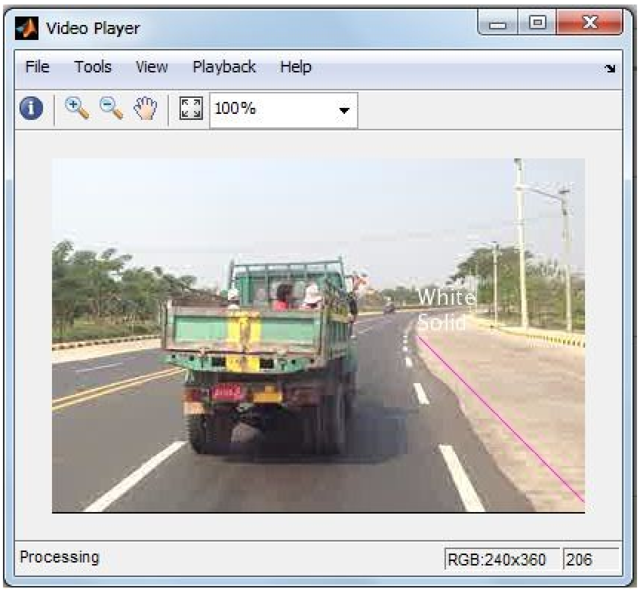
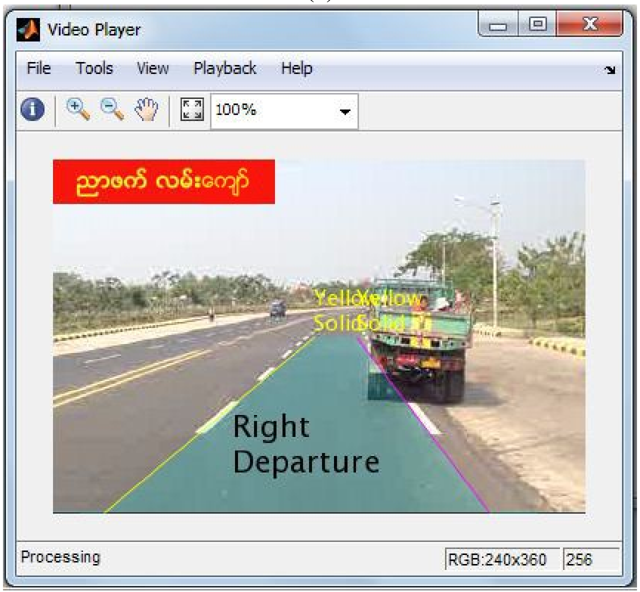
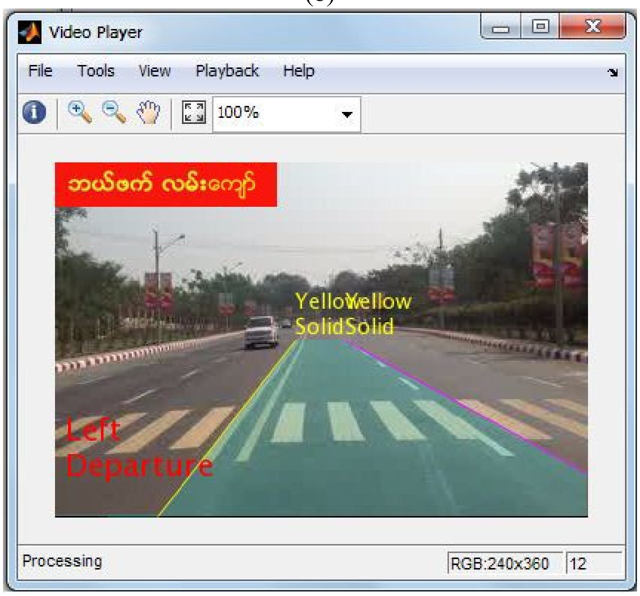


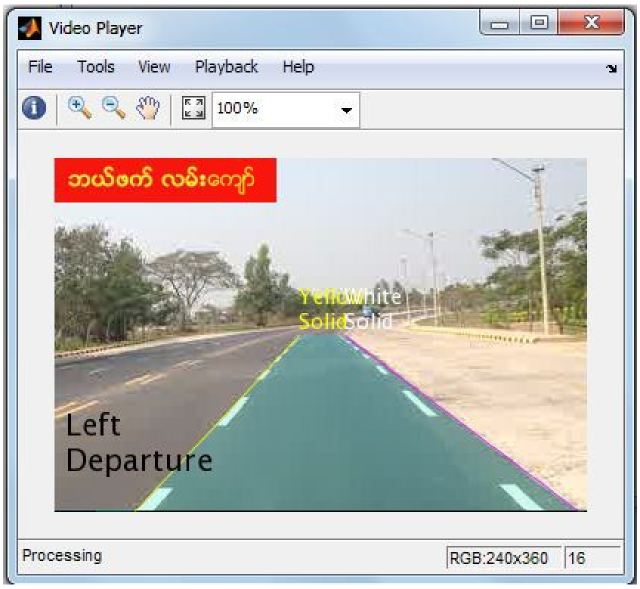
(a)



(b)



(c)



(d)

Fig.5. Lane detection results

Table. I. Accuracy Result for Detection at Different Lighting Conditions

Condition		**Accuracy**
Straight Lane	Cloudy Condition	97.2%
	Sunny Condition	99.2%
Curved Lane	Cloudy Condition	91.7%
	Sunny Condition	95.1%

V. CONCLUSION

In this paper, a lane detection system for departure warning based on video sequences taken from a driving vehicle was proposed. The input video sequences are processed using an image processing techniques and implemented with Matlab.

As most of the lane marks are straight, lanes are detected using Hough transformation. The proposed system can detect road lane markers in a video stream and an unintended departure from the lane. Unwanted noise on the road image is filtered with 2D FIR. The system can also 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.

Although the system can work efficiently on fewer curves lanes, challenges occur from curved roads. Another limitation of the system is its inefficient detection at poor visible conditions especially at night.

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