AUTOMATED CAR DRIVER ASSISTED: ROAD LANE DETECTION AND TRACKING USING VISION SENSOR

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ABSTRACT

A Lane Departure Warning (LDW) system is one of the systems of the Automated Car Driver Assisted system. The lane departure warning system is designed to warn the driver when the vehicle starts to move out from the actual lane without any intention of the driver to change from the initial lane path. This system is designed to decrease the number of road accident those are frequently occurred because of the driver error, distraction and drowsiness. This LDW system can also be applied on many real world applications such as security control freeway, driving training, autonomous navigation and the visually impaired assistant. The LDW system is based on visual sensor that is usually mounted behind the windshield of the vehicle, laser sensor which is mounted on the front of the vehicle and infrared sensor which is mounted either behind the windshield or under the vehicle. While driving a vehicle, it is unknown whether the driver driving with normal behavior or not. Human error such as drowsiness and distraction while driving is the biggest factor of road accidents. A LDW system is a mechanism to warn the driver when the vehicle starting to depart of the lane on the road and help in decrease the number of accidents cause by the problems above. Therefore, this project is focusing on the lane detecting and tracking by using vision sensor. This project purposed is to study the technique used to detect the road lane detection and tracking by using vision sensor (camera). In order to achieve the main objective, the other objectives must be fulfilled are to determine the best algorithm to detect lane and to develop the program of the road lane detection and lane tracking.

The scope of the project is to capture the video of the straight Lebuhraya Pantai Timur (LPT) road scene at the day. The image from the video is process and test with the design program to detect and track the road lane.

ABSTRAK

Sistem Amaran Perlepasan Laluan (APL) merupakan satu bentuk sistem Bantuan Pemanduan Kereta Berautonomi. Sistem APL direka untuk memberi amaran kepada pemandu kenderaan apabila kenderaan mula bergerak keluar dari laluan sebenar dan pemandu tiada niat untuk menukar laluan asal di lorong jalan raya. Sistem ini direka untuk mengurangkan bilangan kemalangan jalan raya yang kerap berlaku kerana kesilapan pemandu, kesesatan dan mengantuk ketika pemanduan. Sistem APL ini juga boleh diaplikasikan kepada situasi sebenar seperti kawalan keselamatan lebuh raya, latihan pemanduan, navigasi autonomi dan pembantu kepada pengguna cacat penglihatan. Sistem APL berdasarkan sensor visual pada kebiasanya dipasang di belakang cermin depan kenderaan, sensor lesor yang dipasang pada bahagian hadapan kenderaan dan penderia inframerah yang dipasang sama ada di belakang cermin depan atau di bawah kenderaan. Semasa memandu kenderaan, ia tidak diketahui sama ada pemandu memandu dengan kelakuan normal ataupun tidak normal. Kesilapan manusia seperti mengantuk dan gangguan semasa pemanduan adalah faktor terbesar kemalangan jalan raya. Sistem APL adalah satu mekanisme untuk memberi amaran kepada pemandu apabila kenderaan mula berlepas di laluan jalan raya dan membantu dalam mengurangkan bilangan punca kemalangan disebabkan oleh masalah di atas. Oleh itu, projek ini akan memberi tumpuan kepada proses mengesan dan menjejaki laluan jalan raya dengan menggunakan sensor penglihatan iaitu melalui kamera.

Ojektif utama projek ini dijalankan adalah untuk mengkaji teknik yang digunakan untuk mengesan dan menjejak laluan jalan raya dengan menggunakan pengesanan dan penjejakan sensor penglihatan (kamera). Bagi mencapai objektif utama, objektif

sampingan mesti dipenuhi iaitu untuk menentukan algoritma terbaik untuk mengesan lorong dan untuk membina program pengesanan laluan jalan raya dan pengesanan laluan jalan raya.

Skop projek ini adalah untuk merakam video jalan raya yang lurus di Lebuhraya Pantai Timur (LPT) pada waktu siang. Imej dari video itu akan diproses dan diuji dengan program yang telah direka bentuk untuk mengesan dan menjejaki laluan jalan raya.

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LIST OF ABBREVIATIONS

ABBREVIATION	MEANING	PAGE
2D	2-dimension	21
APL	Amaran Perlepasan Laluan	v
DSLR	Digital Single Lense Reflex	13
HSI	Hue Saturation Intensity	9
HSILMD	Hue Saturation Intensity Line Making Detection	9
HSV	Hue Saturation Value	9
IEEE	Institute of Electrical and Electronics Engineers	5
LDW	Lane Departure Warning	iii
LPT	Lebuhraya Pantai Timur	iii
P-tile	Therholding technique	7
RGB	Red Green Blue	9
ROI	Region of Interest	7
Spline	Piecewise-polynomial real function	10

CHAPTER 1

INTRODUCTION

A Lane Departure Warning (LDW) system is one of the systems of the Automated Car Driver Assisted system. The lane departure warning system is designed to warn the driver when the vehicle starts to move out from the actual lane without any intention of the driver to change from the initial lane path. This system is designed to decrease the number of road accident those are frequently occurred because of the driver error, distraction and drowsiness. This LDW system can also be applied on many real world applications such as security control freeway, driving training, autonomous navigation and the visually impaired assistant.

The LDW system is based on visual sensor that is usually mounted behind the windshield of the vehicle, laser sensor which is mounted on the front of the vehicle and infrared sensor which is mounted either behind the windshield or under the vehicle.

1.1 Lane Detection and Lane Tracking

Usually, in LDW system, lane detection is one of the steps in getting the more information about the road scene image that have been analyzed. Lane detection and lane tracking is two important task. Lane detection is the problem of locating lane boundaries without prior knowledge of the road geometry. Lane tracking is the problem of tracking the lane edges from frame to frame given in an existing model of road geometry [1].

1.2 Problem Statement

While driving a vehicle, it is unknown whether the driver driving with normal behavior or not. Human error such as drowsiness and distraction while driving is the biggest factor of road accidents. A LDW system is a mechanism to warn the driver when the vehicle starting to depart of the lane on the road and help in decrease the number of accidents cause by the problems above. Therefore, this project is focusing on the lane detecting and tracking by using vision sensor.

1.3 Objective

There are main objective and support objective for this project.

1.3.1 Main Objective

The main purpose of this project is to study the technique used for the road lane detection and tracking by using vision sensor (camera).

1.3.2 Support Objective

In order to achieve the main objective, the other objectives must be fulfilled are:

(i) To determine the best algorithm to detect lane

(ii) To develop the program of the road lane detection and lane tracking

1.4 Scope of Project

The scope of the project is to capture the video of the straight Lebuhraya Pantai Timur (LPT) road scene at the day. The image from the video is process and test with the design program to detect and track the road lane.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this project there are some external sources have been used as references to convey to about the knowledge and ideas that have been established on the lane detection and tracking topic. The sources had been search out from reliable source on the internet such as IEEE webpage and ScienceDirect webpage. The sources that had been used were such as journals and conferences on the same topic and several techniques that have been used for road lane detection and tracking system.

2.2 Lane Model

Lane shape cannot be represented accurately by a simple model, especially in a far-field. A computational cost of a sophisticated lane model is much heavier and may increase the amount of detection error. The left and right lane boundaries are represented by two parabolas with constant curvature on the ground plane (the constant curvature assumption is made during the lane tracking state) [2]. One the perspective mapping for processing, these two parabolas are transform onto the image plane and this model has been used most widely in the existing lane detection system. The model incorporated parallel line and planar ground surface constraints which are suitable for most of the highway applications [2]. A small number of parameter which leads to more accurate and faster parameter estimation is also required for this model. The drawback is the lack of flexibility in representing complicated lane shape [2]. (Yifei Wang *et al.*, 2012)

2.3 Hough Transform

Hough Transform was used to combine edges into lines, where a sequence of edge pixels in a line indicates that a real edge exists [6]. Hough Transform will detect the lane boundary on the image by using the edge data of the road image. This technique detects shapes from image edges, and assumes that primitive edge detection has already been performed on an image. This technique is most useful when detecting boundaries which shape can be described in an analytical or tabular form. Mapping a line detection problem into a simple peak detection problem in the space of the parameters of the line is the key function of this system. The features of a particular

shape within an image can be isolated by using the Hough Transform. It can be divided into two types: classical and generalized. Because it requires the desired features to be specified in some parametric form, the classical Hough Transform is most frequently used for detection of regular curves, such as lines, circles and ellipses. A generalized Hough Transform can be engaged in applications where a simple analytic description of a feature is not possible. Hough Transform works by letting each feature point (x, y) vote in (m, b) spaces for each possible line passing through it, these votes are totaled in an accumulator and if, for instance, a particular (m, b) has one vote, this means that there is a feature point through which this line passes [6]. It means that two feature points lie on that line if it has two votes. If a position (m, b) in the accumulator has n votes, this means that n feature points lie on that line. The algorithm for the Hough Transform can be expressed as follows: 1) Find all of the desired feature points in the image. 2) For each feature point: For each possibility i in the accumulator that passes through the feature point, increment that position in the accumulator. 3) Find local maximum in the accumulator. 4) If desired, map each maximum in the accumulator back to the image space [6]. (Gayathiri Somasundaram *et al.*, 2011)

2.4 Region of Interest

The image processing and computer vision techniques approach were proposed in indentifying the driving environment for intelligent highway vehicles. The proposed approach mainly consists of two consecutive computational steps1. The lane marking detection is used to identify the location of the host vehicle and road geometry as the first step. The ROI (Region of Interest) of the image is defined. Then, they computed the high-color and low-color image of any three consecutive images along the ROI. P-tile (a thresholding technique) technique is used to the image to determine a suitable

threshold value at ROI region and then remove the noise form image by standard opening method. Then, the output from the first step is used in the second step to propose a four-stage algorithm for vehicle detection as information provider on the relative position and speed between the host vehicle and each proceeding vehicle. (Y.J. Wu *et al.*, 2007)

A new platform for the implementation of lane detection is proposed based on a mobile phone. A simple and efficient lane detection algorithm is developed using a Hough transform and implemented on the iPhone due to the physical limitation of the iPhone where respect to the memory and computing power. The iPhone's camera is used to acquire the data (image of the road lane). Then, they had apply smoothing technique, canny edge detector, morphological method and Hough transform to the image. They also defined the ROI to improve the computational efficiency.(Feixiang Ren et al., 2009)

2.4.1 Hue Saturation Intensity

The segmentation other relevant method is based on region growing and clustering. The effectiveness of this method is depended on the measuring similarity capability such as in texture and pixel color information. Relevant information for localization of the visible road area provided by a color-based visual module is depending on the presence of the lane boundary markings and the different lightning condition. In the road image, the road area has characteristics such as the following: 1) most of the lower part of the image was considered as the road area, and 2) road areas have a quasi-uniform color, resulting from the fact that the road area is generally a grey

surface in a more colored environment [6]. Although the useful cues can be provided by the absolute surface color for this task, the response of the color imaging device is mediated by the color of the surface observed, by the light illuminating color and the setting of the image acquisition system. To have better control over variations in pixel values for the same color, and to remove the shadows, the RGB (Red Green Blue) color space must be converted to the HSV (hue, saturation and value) color space [6]. (Gayathiri Somasundaram *et al.*, 2011)

HSI (Hue Saturation Intensity) color model for lane-marking detection, HSILMD (Hue Saturation Intensity Line Marking Detection) is proposed as the new method. In order to detect road surface on host vehicle, the full color image are converted into HSI color representation within the ROI. The recorded difference of intensity distribution of a row of pixels within ROI then is clustered with Fuzzy c-Means algorithm. Thresholds of intensity and saturation are selected accordingly2. Lane markings on various road scenes are detected with simple thresholds and operations. The results then are compared with the same scheme using RGB color model and a different scheme. (Tsung Ying Sun *et al.*, 2006)

2.5 Edge Detection

The parameter in an image is determined by edge detection process. The edge is caused by the difference in brightness from one point to the other point [3]. The edge is defined clearly if the brightness changed sharply. The results of applying an edge detector to an image for road lane detection should lead to a set of connected lines that indicated the road lane. The gradient method for edge detection detects the edge by

looking for the maximum and minimum in the first derivative of the image. Sobel, Prewitt, Roberts and Canny is the well known gradient based edge detection algorithm. In other way, the Laplacian method is used to search for zero-crossing in the second derivative of the image to find the edge. (Worawit Phueakjeen *et al.*, 2011)

The sharp contrast (edge in the image) between the road surface and painted lines or some type of non-pavement surface can defined the lane boundaries. Therefore, edge detectors are very important in determining the location of lane boundaries [4]. Concededly, if the outline of the road can be extracted from the image, the amount of learning data can be reduced by simplifying the image. (Othman O. Khalifa *et al.*, 2009)

The position and direction of the lane boundaries have to be known in order to generate the LDW. Two ways in indicating the lane boundaries are through the magnetic markers or the painted lane boundaries. Usually, the lane boundaries demonstrated a higher intensity than the pavement in an image of the road. A forward-looking camera has been more popular since it can see further down the road than the down-looking one, thus gathering more information on lane boundaries, vehicles and pedestrian [5]. The lane boundaries can be estimated by using the Kalman filter, calculated gradient of the intensity, used the histogram and used the spline (piecewise-polynomial real function) curve. (Sam Yong Kim *et al.*, 2008)

2.6 Lane Feature Extraction

The most commonly used feature in the existing lane detection system in the image gradient or edge. Small computational power and extracting sharp transition in the image intensity is required. A strong edges produces by a well-painted lane markings give benefits to the detection of lane. However, as the environment changes, the lane edge may not be as strong and may be heavily affected by shadows or adverse weather conditions [2]. It has been always difficult task to choose the edge threshold and some existing systems choose a very small value or directly used the image gradient without thresholding. Therefore, many unwanted feature such as edge corresponding to trees, building and shadows are included. The steerable filter is also a well-known for the lane feature detection [2]. Only the line structure detector is built for comparison for the implementation of the filter. The disadvantage of the steerable filter is the filter is an only extracts lane marking which is not suitable for unmarked road. (Yifei Wang *et al.*, 2012)

2.7 Conclusion

Based on the references, the image processing is the essential process in defining the system of the lane detection and tracking by using the vision sensor which is the camera. All the images and data of the road lane are acquired by the camera. Then, various types of image processing methods are applied such as the edge detector, defining the ROI, used histogram and Hough Transform to extract all the information needed from the images.

CHAPTER 3

RESEARCH METHODOLOGY

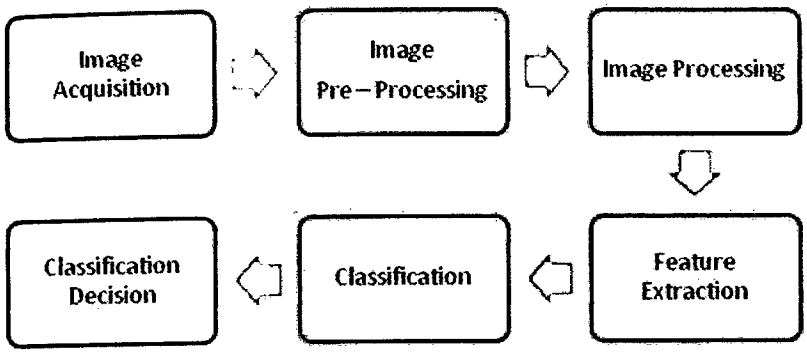
3.1 Introduction

Image input is an important element in image processing. From the image acquired, then it had to be analyzed and interpreted in form of necessary data and removed the noise, in order to display the desired result.

3.2 Procedure

There are several steps involved in image processing to process the data from the image has been acquired.

Figure 1.1: Step in Image Processing



3.2.1 Image Acquisition

A Nikon D90 DSLR (Digital Single Lens Reflex) is used to record the road scene. A 12.3 megapixel resolution of image capturing can give the clear image quality and suitable for image processing especially in detecting the road lane. Then, the images from the video captured were converted to the still image frame by frame. The still images were saved in a format that was readable by MATLAB software which one of it is .bmp (Window bitmap) format.

3.2.2 Image Preprocessing

In this stage, some improvement and enhancement are made to remove the noises for the image processing stage. Therefore, the color processing is done, such as converting the original image to the binary image. Figure 1.2 has shown the example of the image pre-processing where the image is converted from RBG image to Grayscale image.

Figure 1.2: RGB to Grayscale

3.2.3 Image Processing

For image processing stage, there are processes to separate the background from the desired object in the images. There were many types of image processing techniques can be used in this stage such as morphological processing and edge detection techniques. Figure 1.3 has shown the example of image processing. The edge of the image is detected by using the Canny Edge detector.

Figure 1.3: Canny Edge Detection

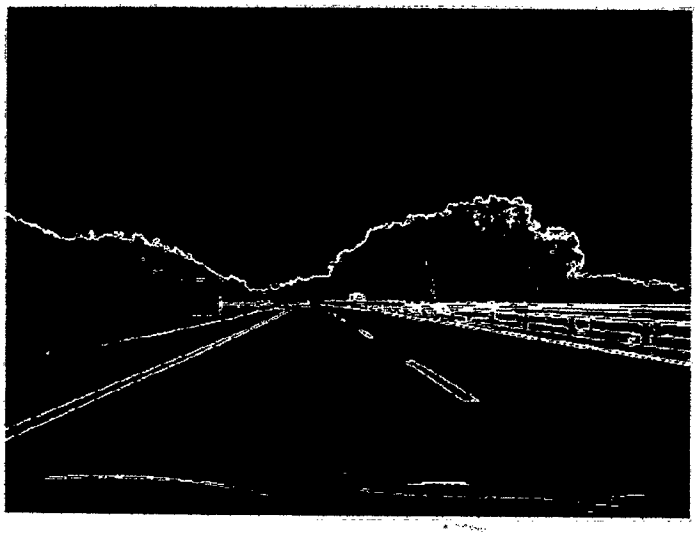


Figure 1.4 has shown the steps used in the image processing for the lane detection algorithm.