

Simple Robust Road Lane Detection Algorithm

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Abstract—Lane detection plays an important role in intelligent vehicle systems. Therefore, this paper presents a robust road lane marker detection algorithm to detect the left and right lane markers. The algorithm consists of optimization of Canny edge detection and Hough Transform. The system captures images from a front viewing vision sensor placed facing the road behind the windscreen as input. Then a series of image processing is applied to generate the road model. Canny edge detection performs features recognition then followed by Hough Transform lane generation. The algorithm detects visible left and right lane markers on the road based on real-time video processing.

Keywords—road lane detection; Canny edge detection; Hough Transform

I. INTRODUCTION

Throughout the last two decades, the requirement of transportation need has increased tremendously. There are more vehicles on the road now, unfortunately that also brings to increase in traffic accidents. Tremendous efforts put into the education of safety driving and development of accident avoidance system.

With the continuous research from the Defense Advance Research Project Agency (DARPA) in recent years, the research in autonomous vehicles has gained interest from researcher worldwide. Vision-based road lane detection has been an active research topic for many systems, such as lane departure warning[1], adaptive cruise control[2], lane change assist[3], turn assist[3], time-to-lane-change[4] and fully autonomous driving system.[1]

Although significant advances have made on specialized systems for detecting individual road types, little progress has been made in proposing a general algorithm to detect a variety of types of road conditions. An effective lane detection system will navigate autonomously or assist driver in straight and curved, white and yellow, single and double, solid and broken and pavement or highway lane boundaries. Furthermore, the system should detect under noisy conditions such as shadows, puddle, stain and highlight.[5]

The algorithm consists of three main parts, which is pre-processing, post-processing and the lane recognition. These parts imitate the human abilities to recognize road lane from viewing with the eyes, analyzing by the brain and then providing an analyzed result. The “human centered” intelligent vehicles will depend on the technical resolution and costing for

different types of conception output such as collision avoidance and lane departure.

This paper contains of five sections, Section I is the introduction. Section II introduces the system architecture. Section III introduces the generation of road lane model based on Hough Transform. Section IV introduces the implementation of the system. The experimental results are described in Section V and conclusions and future works in section VI.

II. SYSTEM ARCHITECTURE

The purpose of the algorithm is to find the features belonging solely to the lanes. While driving on the road with continuous lane marking, the positions of the lanes are not changing significantly over time from the driver’s point of view. This algorithm takes advantage of the smaller region of interest right in front of the moving vehicle.

The lane detection algorithm consists of three stages: pre-processing, post-processing, road lane modeling. Details of these steps and related computations are described in this section.

A. Pre-processing Stage

The first step is low-level image processing, which deals with images from the vision sensor and generate useful information for detection parts. In this stage, image of the road is copied for the computational part. The image is reduced to a smaller region of interest to save computational time as shown in Figure 1. The image is also converted into gray scale as Canny edge detection works with monochromatic image. Noise reduction with image processing such as erosion, dilation and image smoothing are also applied for better useful information.

B. Post-processing Stage

Canny edge detection is implemented in the post processing stage. Lines and edges in the smoothen image are detected in the feature recognition stage shown in Figure 2. Then Hough Transform is implemented to connect discontinuous line and differentiate different lines as in Figure 3. In short, post-processing is one of the most important steps as it ties together feature extraction stage and the road lane modeling stage.

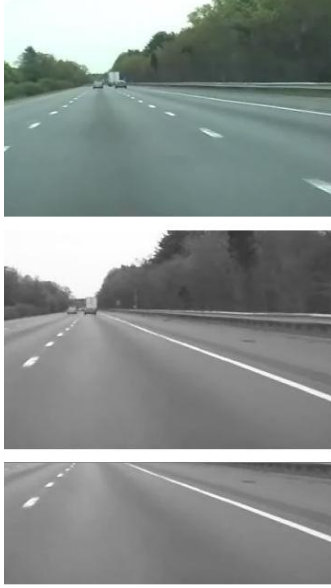


Figure 1. In the preprocessing stage, Original Image(top) is converted into gray scale image(middle). Then the region of interest is reduced focusing on the road to reduce computational time(bottom).



Figure 2. Canny edge detection to extract features of the lane marker.

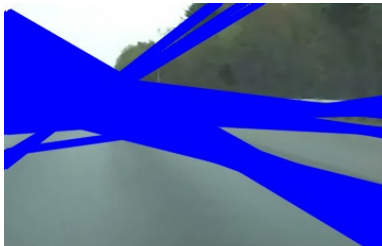


Figure 3. Hough Transform detects relevant lines representing left and right lane markers.

C. Road Lane Modeling

Computation is done to recognize possible left and right lane markers. Parameters of the lines, rho (T) and theta (d) are used for the computation. Grouping similar lines together and then getting an average result. The final result attached on the original image showing the left and right lane marking on the road.

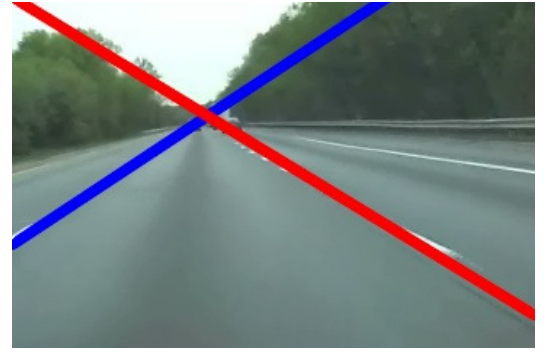


Figure 4. Left and right lane marker combines into linear road model.

III. HOUGH TRANSFORM

The main purpose of Hough Transform is to detect straight lines and curves.[6] Another advantage of Hough Transform is the segmentation result which uses an approach which is less sensitive to noise.[6]

For straight lines detection in an image, the process uses parametric units of the line.

$$T = x \cos d + y \sin d \quad .1$$

where, T represent radius from the origin

d represent angle of the normal from the origin

(x,y) represent pixel coordinates of the line

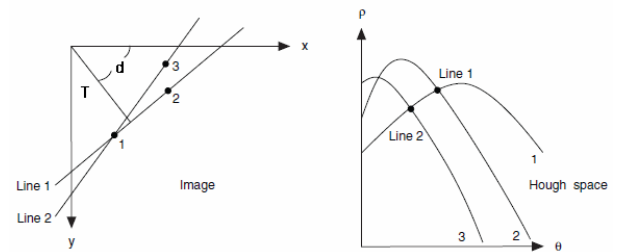


Figure 5. Conversion of image plane to Hough space ;pixel coordination (x,y) to (T,d) .[7]

A point in the image becomes a sinusoid in Hough space; A point in Hough space becomes a line in the image. Sinusoids corresponding to co-linear points will intersect at a unique point as shown in Figure 5.

Besides that, Hough Transform also capable of connecting disconnected line (i.e. disconnect lane marker or obstructed lane marker) using its “voting” threshold properties. This is

because disconnected lines have the same T and d parameter. The same (T,d) values accumulate and conducts a voting system. A threshold of the accumulator is set to provide reasonable result.

IV. IMPLEMENTATION OF SYSTEM

It is important to identify the objectives for any lane detection system as the parameters used to develop the relevant performance metrics can be different for different sets of objectives. A method which works well for an objective may not be suitable into another application. Therefore in order for the algorithm to work in changing road appearances, a generalized algorithm framework is developed.

A. Generalized Algorithm Framework

First component of the algorithm is to generate a road model. The lane detection system is built based on the result from the Hough Transform. Two linear lines which represent the left lane marker and the right lane marker combine into a linear road model.

After the first processing, the information is then refined using additional information about the general characteristic and information from the road model and past image frame.

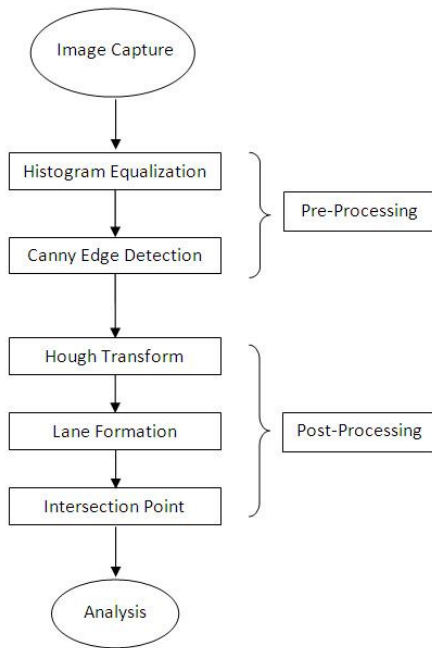


Figure 6: General flowchart of the lane detection algorithm,

B. Assumption and Limitation

Assumptions and limitation of road situations provide a significant improvement to accuracy of detection of lane markers.[8] Knowing the limitation of the system enables the system to work in better ways and reducing false alarm. These assumptions include:

- The road lane markers are visible and consistent.

- The road width is locally constant or with small changes.
- The road lane markers follow strict rules for the appearance
- Exclusion of extreme weather

C. Lane Boundary Generation

Final result of this algorithm is to successfully shown on the original image the left and right lane boundary. After performing Hough Transform, the result shows multiple lines which qualify the condition to becoming the left and right lane boundary as shown in Figure 7. By grouping all the left lane boundaries as a group, and right lane boundaries as another, then find the average gives only one left lane detected and one right lane detected.



Figure 7: Left and right lane marker before averaging.

V. EXPERIMENTAL RESULT

This section presents the performance of the proposed algorithm in the real road scenes. The algorithm manages to detect and extract the left and right lane markers. The proposed algorithm is tested on video images from video grabbed with an on-board vision sensor placed on. These Figure 8-11 shows some of the experimental results of lane marker detections where the lane markers are shown on the original video image. These images shows real local highway scene (in Malaysia) with solid and broken lane markers.

Figure 8, shows a series of road images at good condition, 8(a) and 8(b) show combination of solid lane marker on the left and broken lane marker on the right. The algorithm manages to detect the left and right lane markers successfully. 8(c) and 8(d) show an image with moving vehicle in front and combination of solid and broken lane markers. The algorithm manages to detect the left and right lane markers successfully.

Figure 9, shows detection on road with different markings on the road images. 9(a) shows yellow stripes and arrow on the road image. 9(b) shows thicker stripes on the road image. The algorithm manages to detect the road lane successfully.

Figure 10, obstructions can exist to block the lane markers from detection such as a stationary vehicle on the road side or a moving vehicle. 10(a) shows a motorcycle obstructing the right

lane marker. 10(b) shows vehicles parking by the road side obstructing the lane detection. Both 10(a) and 10(b) also shows detection of road with two different color tones.

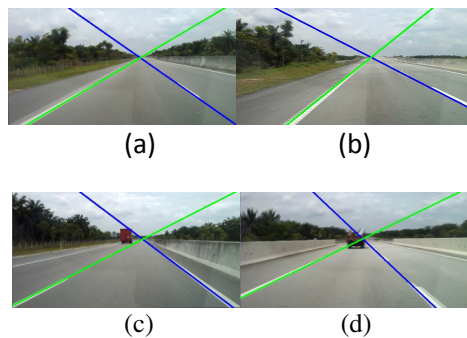


Figure 8 Road detection at good conditions

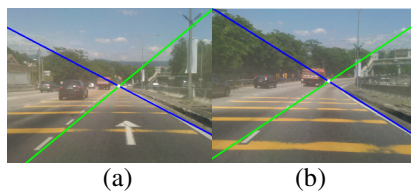


Figure 9 Road detection with different markings on the road

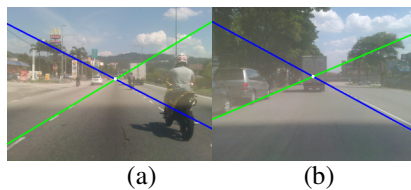


Figure 10 Road detection with obstruction and different color tones.

VI. CONCLUSION

In this paper, a simple robust real-time road lane detection system is tested for accuracy and robustness in real-time configuration. The algorithm passes through a series of low-level image processing to make the useful information easier

to be extracted. Then extracts of road features with Canny edge detection. Hough Transform is applied to find relevant lines that can be used as the left and right lane boundaries. Finally the collected left and right lane boundaries are averaged to get the desired result of left and right boundaries and shown on the original image. To reduce the high computational cost, the image is reduced to a smaller region of interest. Smaller threshold value is applied on edge detection for more complex environments.

For future works, the lane detection will be applied with position tracking to further reduce computational load. With real-world positioning applied into the image, distance and time to departure can be obtained. With the combined parameters the development of a new lane departure warning system will be introduced.

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