Road Lane Detection Using H-Maxima and Improved Hough Transform

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***Abstract*— A fast and improved algorithm with the ability to detect unexpected lane changes is aimed in this paper. A short segment of a long curve has relative low curvature which is approximated as a straight line. Based on the characteristics of physical road lane, this paper presents a lane detection technique based on H-MAXIMA transformation and improved Hough Transform algorithm which first defines the region of interest from input image for reducing searching space; divided the image into near field of view and far field of view. In near field of view, Hough transform has been applied to detect lane markers after image noise filtering. The proposed method has been developed using image processing programming language platform and was tested on collected video data. Promising result was obtained with high efficiency of detection.**

Keywords-H_MAXIMA, Hough Transform, lane markers

I. INTRODUCTION

Malaysia is paying a heavy price due to road accidents, and the cost to the economy last year was about RM9.3bil [1]. Recent statistic shows that the number of fatalities in Malaysia increased to 6,872 deaths in in last year. Bukit Aman Internal Security and Public Order Department revealed that the total number of road accidents has increased to 414,421 [2]. In a separate online survey by the community project Malaysians Unite for Road Safety (MUFORS), 61.6% of the respondents believed that human error like improper vehicle's deviation or unintentional lane change is one of the main causes for road carnages.

Changing lanes in traffic is a surprisingly complex task. To reduce the probability of a vehicle's straying out of lane, technique for driving assistance has received considerable attention, particularly lane markings detection technologies which have very significant market potential and high practical value.

II. RELATED WORK

Existing techniques in study of lane detection technology have diversity analysis angle and variety of advantages, disadvantages. The fundamental aspects of lane detection approaches are based on different features, including the road color and texture features based detection, the road edge features based detection and template matching detection.

In [3] [4] contrasting color and intensity on road face are selected as important and preferred analysis elements to distinguish lane markings on road face. Typically, colors influenced by environment illumination sensitive easy led to unsatisfactory results. The methods by implementing edge detection are presented in [5][6]. The template matching technique used in this study is to compare portions of images to match with a template. The template designed by priori information, defining some road scene characteristic to the observed image. The matching process moves the template image to all possible positions in the source image in order to find the best match between the template and the image. To describe different road structure, several lane models have been presented here from straight lines [7], [8] to parabolic curves [9], [10] and B-spline curve model [11]. The technical difficulties of this type of algorithm is to use few templates describe variety of road scenes

Although the Standard Hough Transform. (SHT) is a robust technique [12] for detecting discontinuous lines common techniques used for lane detection in most literatures [14] [15][16], the computational cost of SHT is still expensive.

III. PROPOSED METHOD

General research methodology can be described as shown in the following block diagram in Figure 1.

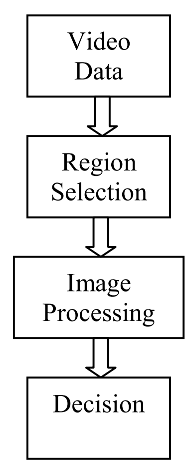

Figure 1. General Research Methodology

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A. *Region of Interest Selection*

Data collection from the camera between the front windscreen and the rear-view mirror is the source of image frames delivered to the system. When the camera lens direction parallel to the ground, the taken image frames can be divided to foreground and background fields. Choosing an appropriate ROI will not only minimize the search area in images but also diminish the interference from extraneous objects.

The farthest objects in the image frames which are above the horizon, consisted mainly of clouds, sky, hills or far distances objects, would considered as less interest region for lane detection purpose. The greatest region of interest extends from the bottom line of the image frame to around 15 meters in front of the vehicle, where all the important objects are located, like lane markings, pedestrians and other vehicles. Video images are obtained by a camera with image dimensions of 640 × 480 pixels, and the ROI defined as 2/3 of image size height equals to 320 pixels. 2/3 of image height is an approximation for the region between the horizon and the bottom line of the image. The width of ROI is the same as the image width. An example is given in Figure 2 where the x_0 and x_1 is the left boundary and right boundary of the ROI, and y_0 is the top boundary, y_1 indicate the bottom boundary.

Figure 2. An example of ROI selection

B. *Extended And H-Maxima Transformation (Image Processing)*

A marker extraction scheme based on the H-maxima transform is introduced here to obtain the optimal segmentation result from the pre-processed image. In grayscale colormap light-colors have higher value, dark-color values is approximated to 0. H-extrema transformations provide a function to filter the image extrema using a contrast criterion [13]. The h-maxima transformation suppresses all maxima whose depth is lower or equal to a given threshold level. Image minima and maxima are important morphological features as they often mark relevant image objects: minima for dark objects and maxima for bright objects so it's perfectly match with road characters where lane markings represent maxima region in images. The h-maxima transformation can be defined by the formula below:

$$HMAX_h(g)=R_P^{\lambda}(g-t) \quad (1)$$

Where *g* expresses an intensity image; the h-maxima transform H is used for suppressing all maxima in the intensity image; *t* means threshold. *R* represents the reconstruction. R_P^λ is the morphological reconstruction by g. The extended minima EMIN are defined as the regional minima of the corresponding h-minima transformation, the extended maxima EMAX being defined by:

$$EMAXh\ (p)=RMAX[HMAXh(p)], \quad (2)$$

$$EMINh(p)=RMIN[HMINh(p)]. \quad (3)$$

C. *Improved Hough*

It can be known by the theory and implements of Hough transform, the classic Hough algorithm has heavy calculation burden resulted in ineffectiveness to satisfy real time request. To reduce computation cost, this paper use prior knowledge, improved two aspects according to lane detection based on Hough. First, define ROI area. Hough is adopted within ROI limits, reduce image pixels which join Hough transform; second by utilization prior knowledge determine a reasonable search range of angle θ.

About the second improvement can be explained as following lines. In Hough space γ is Polar Radius, θ is Polar angle. Experiment analysis proves that Hough transform detected lines polar angle fluctuated narrowly in a continuous stream flowing. The search range of θ will be restricted based on detected θ in the Hough transformation of the previous image frame. Thus the polar angle search scope is defined in the region near θ, for example search scope can be (θ max-Tθ, θ max+Tθ) where Tθ is a tolerance. In this way it reduces the computation time and has the effect of reducing the number of useless voting process, thus enhancing the visibility of the real lane information in the image. The detailed description of each step given below:

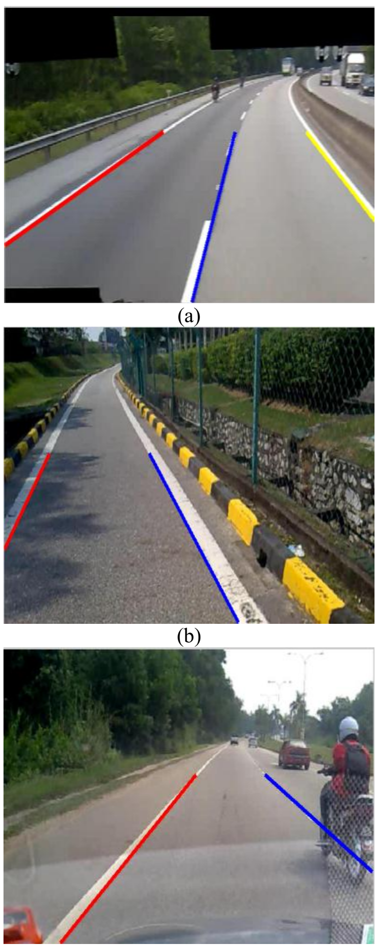
- Using initialized frames obtain prior knowledge to determine a reasonable search range of (r, θ). Between its maximum and minimum values establish a discrete parameter space.
- Create and initialize a two dimensional accumulator array H(r, θ) with zeros.
- Scan in ROI of the image and collect edge points where the edge pixels have been assigned a value of 1. Sample points set { 〖(x〗_i,y_i)|i=1,2,..,T} will be selected in turn until all elements are processed; traversing the θ value and calculate r value.Thus get the values of

parameters(r, θ); H(r, θ) = H(r, θ)+1.The array of H(r, θ) is accumulated by 1.

- By repeating procedures as descripted above, the array H(r, θ) has been built up. Abandon θ values out of range (θ min+Tθ, θ max-Tθ) then find the maximum value of the accumulator (r, θ); determine the T strongest straight line.

IV. RESULTS AND CONCLUSION

In this paper, the result discussion is focusing on the real time road lane detection and comparisons of two image processing techniques. The lane detection algorithm presented has been tested on both straight and curved lanes. Figure 3 shows the detection results for the proposed technique with different roads condition - shapes, shadows, noises. Experiments show that this algorithm can achieve fairly good performance in different kind of road conditions.



(a) (b) (c)

Figure 3. Road Lane Detection with 3 different data

In image (a) and (b), it shows this method can fit for different curvature of road. In (b), the strong shadow or motorcycle seen in (c) cut off connections of lane markings will not interfering the detected result. Experiments show that this algorithm can achieve fairly good performance in straight and curve road conditions. Computation time comparison result between improved Hough and Classic Hough listed as below .The whole processing time of the proposed system is about 0.0337 seconds on average and the error rate is 4.77%. The simulation has been processed on a DELL Inspiron laptop with CPU N450@1.66GHz. The result shows that on average the efficiency has been raised significantly as shown in Table 1 and Table 2.

TABLE I. COMPUTATION TIME COMPARISON RESULT BETWEEN IMPROVED HOUGH AND CLASSIC HOUGH

Frame #	Improved Hough	Classic Hough
1-100	0.068698s	0.083978 s.
101-200	0.025170s	0.060881 s.
201-300	0.024774s	0.049680 s.
301-400	0.025885s	0.046137 s.
401-500	0.023982s	0.0424007s
Average processing time	36ms/f	56ms/f

TABLE II. CORRECTION RATE COMPARISON RESULT BETWEEN IMPROVED HOUGH AND CLASSIC HOUGH

	Correction Frames	Total Frames	Total time /s	Average time ms/f	Correction rate
Standard Hough	10884	12000	432	36	90.70%
Improved Hough	11439	12000	288	24	95.33%

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