Partition based Hough Transformation for Real Time Road Lane Detection

Amit Bhati¹, R.K. Somani²
¹²Department of Computer Science & Engineering,
²Institute of Technology & Management,
NH-79, Near Bhilwara Bypass, Bhilwara
¹Email- amitsbhati@gmail.com

Abstract- An integral component of Autonomous Driver Assistance system is the robust detection and tracking of lane markings. It is a rigid problem due to large appearance variations in lane markings caused by factors such as improper illumination (transition from day to night), occlusion (traffic on the road), shadows from objects, etc. In this paper, we present a robust partition based lane detection and tracking technique that deals with lane curvature, improper lane marking, lane changes, ending, splitting and merging of road lanes. We investigate the effectiveness of our algorithm on challenging different scenario in different daylight and night-time road video sequences. The proposed algorithm partition the camera captured image into several slots and tries to detect the lane separately. After detection the lanes in different splits it merges the partitions to find the final probable lane boundaries.

Keywords – computer vision, Lane detection, driver assistance system, Partition based Hough Transform.

I. INTRODUCTION

In the recent years, there has been emergent interest in intelligent vehicles. A prominent initiative on intelligent vehicles was created by the U.S. Department of Transportation with the job of avoidance of highway crashes. The constant intelligent vehicle research will transform the way vehicles and drivers interact in the future. One of the main reasons for the accidents encircling the world is the lack of attention of the driver. A driver may get diverted by many things like change the song from the music player, some activities by persons in the vehicle, etc. But out of all, the main cause is the drowsiness that may be due to anything like night shifts, heavy workload, etc.

There has been a considerable amount of research has been done in the field of vision based road lane detection and tracking. This vision based localization of the lane marking can be separated into two sub problem: lane detection and tracking. Real time road lane detection is the problem of finding the lane boundaries without and information about road geometry and other property. The majority of lane detection techniques are edge based. Subsequent to an edge detection step, the edge based techniques arrange the detected edges into significant structure (lane markings) or fit a lane model to the discovered edges. In the contrast most of the edge based techniques use straight lines to represents the lane boundaries. Others used more complex model such as parabola, hyperbola, B-spline etc. Along with this Hough Transform (HT) [2] is one of the popular technique for detecting line and curves, but in lane detection literature it is generally preferred for line detection only. This transformation is generally work after an edge detection step on gray scale images. In addition the Hough Transform, many diverse techniques also have been applied for lane detection like, dynamic programming [3], neural networks [4, 10], and deformable template matching [5].

On the other hand, lane tracking problem involve the tracking the road lane edges in each frame given an image sequence. Many techniques have been proposed for lane tracking. Among them the Kalman filtering [6, 8, 9], and particle filtering are commonly used for modeling the estimation problems.

II. HOUGH TRANSFORM BASED LANE DETECTION

A. Hough Transform- An Overview–

Hough Transform (HT) [2, 7] is a method to detect uninformed shapes in images, given a parameterized description of the shape in problem. Hough transform can detect flawed instances of the searched shapes. Besides, HT is tolerant of gaps, and image noise has negligible effect on the outcome. The simplest type of the HT is the line
transform in which lines are the target elements required by the transformation. Representing a line in polar form (Equation 1) indicates that its normal is passing through point \((x, y)\) drawn from the origin point to \((r, \theta)\) in polar space. These are represented by the dashed lines in Figure 1.

\[ x\cos\theta + y\sin\theta = r \]  

For each point in the \((X, Y)\) plane and on the line the values of \(r\) and \(\theta\) are constant. Hence for a given point in the \((X, Y)\) plane we can locate the lines passing through the point in terms of \(r\) and \(\theta\). Passing a range of lines at changeable angles \([0, 2\pi]\) and varying \(\theta\) accordingly then it is probable to calculate the value for \(r\). By having a set of lines passing through a point and with calculating the \(r\) and \(\theta\) values for the lines at that point, a Hough space can be produced (Figure 1). Distributing the results of such computations to “bins” and increasing their value or “vote” for each result that is positioned in them, an addition array can be built. The greater the vote values of the bin resulting the elevated the probability that it is a point is on the line.

### Figure 1. Linear Hough Transform

**B. Hough Transform for Lane Detection**–

In the classical Hough Transformation based solution detect the edges with the black & white threshold to strongly detect the white boundary of road lanes. The camera fetched frames get converted into binary image with a threshold value. Then canny edge detection for edge detection is applied. These images with clusters of edges are feed into Hough transform for detecting straight lines. The Hough lines having \(\theta\) value less than 10 are neglected as they are near to horizontal. With assuming that vanishing point is close to the image horizontal center midpoint position is calculated.

For finding the correct lane the best closest match to line is search from Hough transform. The response search scan the edge detected image part step by step to skipping black pixel and finding for some continuous white pixel and then again look for black pixel and so on. In this manner it searches the possible lane marking. For true detection it votes each line for best match. If any line \(i\) having \(\text{votes} [i] > \text{votes} [\text{bestmatch}]\) these lines are mark as best match for detection.

**Figure 2. Road Lane Detected using classical Hough Transformation**
III. PARTITION BASED HOUGH TRANSFORM (PHT)

The classical HT approach processes the complete vision data in order to detect the lines. This situation has two main drawbacks. First, the occluded lines (i.e., another car passing through the line) become noisy since the transformed relative intensity of the line reduces. Second, the relative intensity of the lines also reduces at the curves in the road.

The proposed solution splits the road image into partitions, where the sizes of the partitions are inversely proportional to the distance of the partition to the vehicle. After the image is partitioned, several preprocessing steps are required. These preprocessing steps should be fast enough because the Hough transform is already computationally costly for real-time applications. After fetching frames from the camera, we convert them into grayscale images. Then, Canny edge detection with a threshold value is applied. Now, this preprocessed frame is split into partitions. Now, probabilistic Hough transformation is applied to each partition. This operation gives several hough lines in the partition. Now, cumulative height is calculated so that we can combine all the lines in the same Hough space.

Now, the slope of the lines is calculated, and the lines having slope beyond threshold (i.e., -0.30, 0.30) are rejected. Now, we mark and draw the detected road lane edges and add cumulative height because lines detected in the partition have y-coordinate value starts with 0. Now, after detecting lanes separately in each partition, it’s the time to combine all partition to get the final result. At this final stage, all partitions get combined, and their detected lane coordinates get mapped into the final combined image.

Figure 3. Block Diagram of PHT

(a)       (b)
IV. EXPERIMENTS & RESULTS

A. Setup--

The approach proposed in this study is executed and tested on a relatively short video sequence of a highway drive in different conditions. In addition, the proposed approach is compared with the classical Hough transform where the entire image is processed and the most intense lines are accepted as candidate lines. The properties of the video are as follows.

<table>
<thead>
<tr>
<th>Camera Position</th>
<th>Front Console of the car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>512 X 288</td>
</tr>
<tr>
<td>Frame Rate</td>
<td>30</td>
</tr>
</tbody>
</table>

The widths of the partitions are 40, 10, 10, 10 and 20 percent of image height is taken from top to bottom. And the heights are 40, 10, 10, 10 and 20 percent respectively as shown in Figure 4. These values are given according to the position of the camera. An exact dimension of the partitions is not very critical. The only idea is to put more concentration on the far regions of the camera view. After the partitions are calculated, Hough transform is applied to every partition as described in the previous section. The most promising two lines are assigned as the candidate lane markings. But there may be less than two lines if the intensity of the calculated lines is less than an empirically assigned threshold. The experiment shows that the proposed approach usually detects only two lines most of the time.

B. Results--

The proposed approach managed to detect and track the road lane in most of the sequence. In addition, false positives are reduced to a competent level. In order to validate the results, the proposed approach is compared with the classical Hough Transform approach.

The major differences between the classical and the PHT are shown in Figure 5. The images on the left hand side are the detected or missed lines by the classical approach. The right hand side images are the outputs of the new approach for the same frames which show that the new approach is more robust and accurate.
Figure 5. Differences between classical Hough transform (a, c, e) and proposed approach (b, d, f).

The computational cost of the proposed approach can be compared as follows. The average processing time is 66.23 milliseconds for a laptop PC with Intel’s core i5-3210M processor at 2.50 GHz whereas the average time of the classical approach is 37.76 milliseconds.

Figure 6. Plot for correct tracking rate versus frame rate
IV. CONCLUSION

Lane tracking is one of the most important tasks in autonomous driving. This paper has proposed a partition based HT solution to the problem. The system partitioned the image to apply Hough transform for detecting the candidate and lane boundaries. The performance of the resulting system is increased.

However there are certain assumptions and shortcomings of the proposed approach. First of all, variable lighting and road conditions necessitate adaptive color remapping. Although this is beyond the scope of this work, it is vital for a final product. In addition, the proposed approach models the lane boundaries as lines, therefore an approximation is expected at curves. However, it is also possible to use combination of line segments which are detected at each image partition.

REFERENCES