Analysis of Lane Detection Techniques using openCV

Sunil Kumar Vishwakarma[1]
Information Technology
AIMT Lucknow, India
sunilvishwakarma83@gmail.com

Akash[2]
Computer Science & Engineering
SRMCEM Lucknow, India
cmaster.akash@gmail.com

Divakar Singh Yadav[3]
Computer Science & Engineering
IET Lucknow, India
divakar.yadav@ietlucknow.edu

***Abstract*-Lane detection is one of the most challenging problems in machine vision and still has not been fully accomplished because of the highly sensitive nature of computer vision methods. Computer vision depends on various ambient factors. External illumination conditions, camera and captured image quality etc. effect machine vision performance. Lane detection faces all these challenges as well as those due to loss of visibility, types of roads, road structure, road texture and other obstacles like trees, passing vehicles and their shadows. There are several lane detection methods having their own working principles and backgrounds, merits and demerits.**

We have used Receiver Operating Characteristic curve (referred to as ROC hereafter) and Detection Error Trade-off curve (referred to as DET hereafter) which establish the accuracy of computer vision methods.

We have studied and analyzed several lane detection methods. The performance of two methods has been analyzed and compared using standard computer vision performance evaluation methods and it was found that method based on Canny edge detection was better than the other one based on Sobel operator. Its performance was established and presented better results when plotted using DET and ROC.

Keywords—lane detection; computer vision; confusion matrix; ROC curve; DET curve:

I. INTRODUCTION

Lanes are the white markings on the road parallel to its direction, usually two in number. Lane detection is very closely associated part of driver assistance systems and is highly expedient for driving automobile. Tracing white markings (or similar ones) on road, capturing and processing images using a camera which is mounted in front of the car is called Lane Detection. Lane detection and its tracking is significant element for vision based driver assistance system. Main purpose of these systems is to prevent crashes due to unintended lane departure movements produced by tired drivers. Previous method [1] was used to detect the obstacle on the road and the distance of the obstacle with respect to vehicle as well as lanes structured road. Another performance evaluation method [2] for lane detection was used using three different edge detection operators. For evaluation of performance Abutaleb's higher order entropy binarisation algorithm [3] was used. Roads can be categorized into two groups on the basis of their marking:

(i) Structured road,
(ii) Non structured road

Roads with marking are called structured roads.
Roads without marking are called non-structured roads.

Lane detection on structured roads is comparatively easy rather than non-structured. Lane detection has been a challenging task for all types of roads such as road having single marking, multiple-marking, arched roads, different lighting conditions, shadow of the trees, objects, blockage of visibility, dissimilar texture of the roads, and different weather circumstances. Lane detection can also be applied for the roads having raised pavement markers.

II. COMPUTER VISION AND LANE DETECTION

A. Computer Vision

Transformation of data from a video or still camera into either a conclusion or a new representation is called Computer Vision. A number of transformations are done for accomplishing a specific goal. The input data may include some contextual information such as "the camera is mounted on a car" or "a laser range finder points out an entity 4 meter away". The conclusion might be "there are 1800 mangos in this tree", "there are two persons in this scene" or "17 tumor cells are there on this slide".

B. Challenges with Lane Detection

Different lighting circumstances:
Changing illumination on road during morning, noon and evening time is a major challenge for lane detection.

Different weather circumstances:
Different types of weather include cloudy, windy, rainy, sunny, stormy, foggy and peaceful weather. The weather condition is rarely constant for a given day and varies from time to time.

Curved roads:
If some or all part of road gradually diverges in spite of being straight, then it is called curved road. Lane markings also follow the same curve on the road.

Roads without Lane mark (Unstructured Roads): If the road is not having any lane marking then it is called unstructured road. Lane detection for these roads requires a more robust and effective technique.

Preceding vehicle, Shadow of tree:
Due to shadow of the tree on the road and preceding vehicle it is difficult to detect the lane as it changes the illumination and images captured.

Blockage of visibility:
While travelling, blockage of visibility due to fog, preceding vehicle is also a challenge for lane detection. This blinds the camera sometimes or restricts its view.

Different color:
Due to shadow, day light, evening, color information of the road is also affected which changes the color of images getting captured.

Different texture:
The variation in texture of the road because of non-uniformity is also a challenge for lane detection.

III. PERFORMANCE MEASURING PARAMETERS

Receiver Operating Characteristic Curve (ROC curve), Confusion matrix, and Detection Error Trade-off Curve [7] (DET curve) are some performance measuring parameters which are used for measuring performance of Computer Vision algorithms. When any of the curves is plotted for two methods, the method corresponding to curve having larger area under it is more accurate [7].

It may be possible to guess the performance of an algorithm logically, and to guess its efficiency. But in this case there are normally too many primary assumptions are in use, or the task is also high dimensional that we cannot end up with acceptable results, unless we empirically run the algorithm on some test cases with known results and ourselves validate its correct or incorrect working. So performance is almost universally measured empirically, by running the program on a large set of input data whose correct outputs are known and counting the number of cases in which the program produces correct and incorrect results.

Each specific test that is accomplished can produce one of four possible results:

True positive: It is also called true acceptance and it occurs when a test that should produce a correct result does so, later on referred to as TP.

True negative: It is also called true rejection and it occurs when a test that should produce an incorrect result does so, later on referred to as TN.

False Negative: It is also known as false rejection or type I error and it occurs when a test that should produce a correct result actually produces an incorrect one, later on referred to as FN.

False Positive: It is also called as type II error or false acceptance and it occurs when a test that should produce an incorrect result actually produces a correct one, later on referred to as FP.

We have used OpenCV [4], which is a C language based computer vision library and it was designed for computational efficiency with strong focus on real-time applications.

IV. TOOLS AND LIBRARY USED

A. OpenCV

OpenCV is an open source computer vision library. The library is written in C and C++ and runs with Windows, Linux, and Mac OS.

OpenCV was designed for computational effectiveness and with a strong emphasis on real time applications. OpenCV can utilize the advantage of single computing machine with two or more cores and is written in improved C. If someone wants extra automatic optimization on Intel architectures, one can buy Intel's Integrated Performance Primitives libraries that cover low-level optimized procedures in many diverse algorithmic areas. OpenCV automatically practices the suitable Integrated Performance Primitives library at runtime if that library is installed.

One of objectives of OpenCV is to provide a simple-to-use computer vision infrastructure that aids individuals to develop fairly sophisticated vision applications rapidly. The OpenCV library contains over 500 functions that can be used in many areas of vision including factory made goods examination, medical imaging, safety, tuning of camera, remote sensing, mobile mapping, stereo vision, and robotics. Since computer vision and machine learning go hand-in hand. OpenCV also comprises a full, general-purpose Machine Learning Library.

V. OUR APPROACH

We have used Canny [5] and Sobel [6] and implemented lane detection techniques. In our lane detection techniques we have used a camera mounted in front of the vehicle. On the basis of Receiver Operating Characteristic (ROC) curve and Detection Error Tradeoff (DET) curve performance of these lane detection techniques has been measured. These curves are the standard parameters for assessing the performance of an algorithm in Computer vision.

Confusion matrix has been used for finding FP, FN, TP and TN and on the basis of confusion matrix FP rate, FN rate, TP rate, TN rates have been calculated.

Finally DET and ROC curves have been plotted on the basis of confusion matrix using MATLAB and performance of each method is analyzed.

VI. RESULT AND DISCUSSION

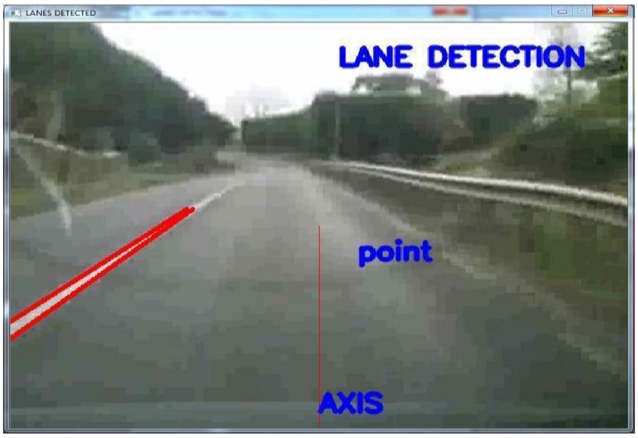

Fig.1: Lane Detection by Canny

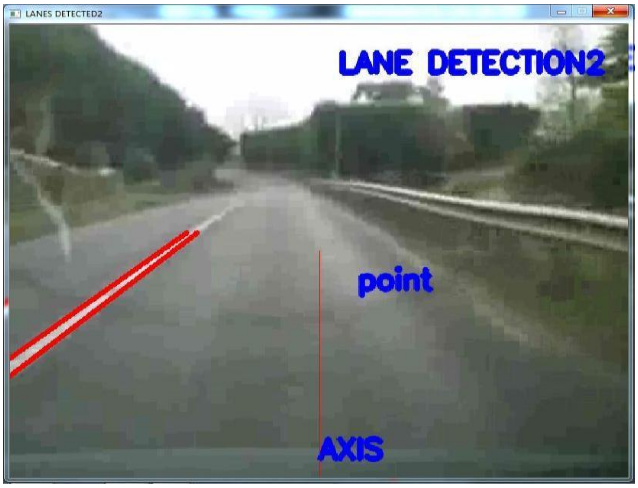

Fig.2: Lane Detection by Sobel

After the development of working code for lane detection in openCV, the code was run on several videos and resulting confusion matrix data were saved in CSV files. A snap shot of both the methods has been shown in Fig.1 (Canny) and Fig.2 (Sobel). Both the methods generated their own data for confusion matrix. Later on data were processed further and Receiver Operating Characteristic (ROC) curve (Fig.3) and Detection Error Trade-off (DET) curve (Fig.4) were plotted based on the same data, which are standard techniques of evaluating computer vision algorithms.

CSV files also contained program generated duplicate data which created lots of problems while plotting these curves. This duplicate data created straight lines parallel to x and y axis which produced kinks in the curve and affected its smoothness. This duplicate data was removed manually and vectors to be plotted were equalized on length. For plotting the graph Matlab [8] was used. Graphs were plotted and both the methods were compared with the graphs of two different colors, green for Canny and blue for Sobel.

Two different colors of curves on both DET and ROC made it very easy to visually judge the performance of two methods.

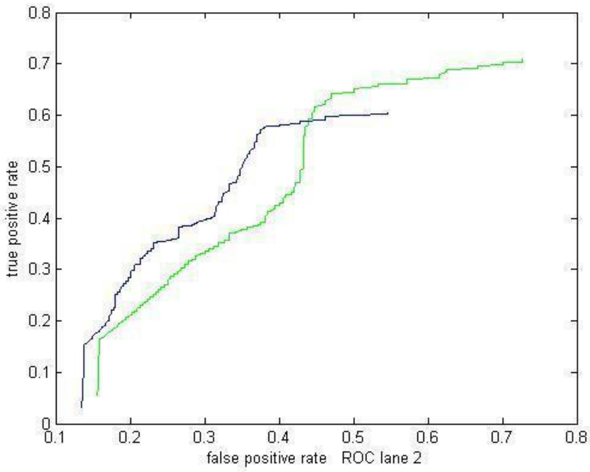

Fig. 3: ROC Curve

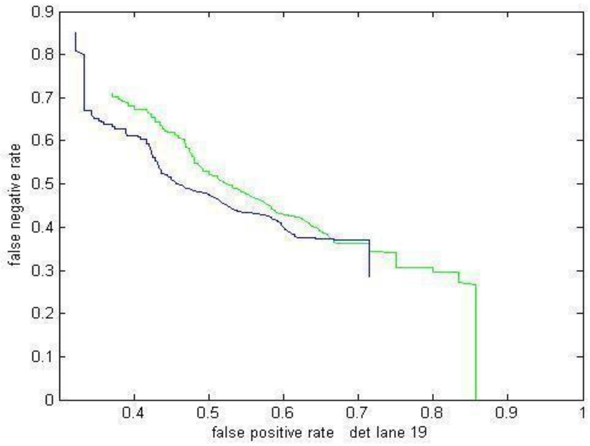

Fig.4: DET curve

It is quite visible from Fig.3 and Fig.4 that green color (Canny) curve has greater area under it as compared to blue color curve (Sobel) which obviously testifies that method based on Canny is better.

VII. CONCLUSION

We reviewed the theoretical background about lane detection methods and their properties. It has already been stated that DET curves plotted for two methods, the one with greater area under it is better in terms of accuracy (same is with ROC).After analyzing the performances of both the methods it is verified that method 1 (green curve) based on Canny edge detection is better than Sobel operator based lane detection method 2 (blue curve) as it covers greater area.

VIII FUTURE SCOPE

In this paper we have used lane detection for structured roads. Lane detection method can further be extended to cover unstructured roads. Also the whole lane detection depends on selection of thresholds for detection of edges. Because ambient illumination conditions, color, texture of roads is not fixed, these methods face lots of issues. Adaptive thresholds can be used instead of fixed thresholds, which will improve the performance at least with respect to external illumination.

We have tested our methods for camera fixed in front. Bird eye view camera can also be explored and studied to bring it within the ambit of these methods.

REFERENCES

[1] M. Bertozzi, A. Broggi: GOLD - A parallel real-time stereo vision system for generic obstacle and lane detection. IEEE Trans. Image Processing, 7:62-81, 1998.

[2] Ali Al-Sarraf, Tobi Vaudrey, ReinhardKlette and Young Woon Woo: An Approach for Evaluating Robustness of Edge Operators using Real-World Driving Scenes ,2008 IEEE.

[3] Y.W. Woo, Performance evaluation of binarisation of scanned insect footprints, In Proc. Combinatorial Image Analysis, pages 669-678, 2005.

[4] Gary Bradski, Adrian Koehler, "Learning OpenCV, O'Reilly,2008.

[5] J. Canny. A computational approach to edge detection, IEEE Trans. Pattern Anal. Mach. Intell., 8:679-698, 1986.

[6] I. Sobel and G. Feldman. A 3x3 isotropic gradient operator for image processing, talk presented at the Stanford Articial Project in 1968.

[7] Performance Characterization in Computer Vision A Tutorial: Adrian F. Clark and Christine Clark VASE Laboratory, Electronic Systems Engineering University of Essex, Colchester, CO4 3SQ, UK.

[8] MATLAB® & Simulink® Release 2007b.