License Plate Tracking using Gradient based Segmentation

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***Abstract*— Of late, auto detection of the license plate and electronic reading of license-plate becomes essential for various applications including security and other regulatory purposes. Full detection of license number is two steps of job namely, (i) License plate location detection and (ii) Character recognition. However, detection of license-plate in a snapshot is limited by the fixed placing of a camera and illumination level.**

Gradient-based segmentation uses change in intensity level in the image to determine the location of the license plate, and it has been studied in this paper. Sobel operator is used for determining first order derivative in the technique. It is generally used for edge detection. Here, Sobel magnitude is used to get edge points to determine license plate location. Method also uses filter based on Hue, Saturation and Value channel (HSV) to filter the region of interest (ROI). Proposed techniques can be e□ectively applied for license plate location tracking irrespective of the location of the vehicle in the frame. It provides high accuracy even during the wide variation in imaging condition. It is based on image segmentation using OpenCV and does not involve any machine learning tool. Experimental results along with the pros and cons of this method are also discussed.

Keywords*— Vehicle identification, license-plate detection, Sobel Operator, gradient-based segmentation and image processing.

I. INTRODUCTION

Smart city concept is getting popular in developing nation like India. Intelligent tra□c and transportation system is one of the significant challenges in the development of smart cities. With the rise in popularity of ITS (Intelligent Transport Systems), vehicle identification emerged as a growing and challenging research issue [1]. License plate recognition system is major aspect of vehicle identification. It is quite problematic because of non-uniform plate formats and the variation in outdoor illumination conditions during image acquisition. Hence, the majority of methods work only under predefined conditions such as limited vehicle speed, fixed illumination, stationary backgrounds and designated routes. Vassili et al. implemented a novel adaptive image segmentation technique (SCWs) [2] for license plate location tracking. It uses statistical tools on local irregularities of the image to extract license plate location. It scans the whole image and extracts the region of interest based on its mean and standard deviation value compared to its surrounding. The works on [3-5] are based on fuzzy logic. These methods use magnitude of gradient and compute its local variance in an image. Zimic et al. [6] uses fuzzy logic to achieve a very high success rate in extracting license plate location. He makes some assumptions and achieved 97% success. Larcoa et al. [7] uses the Convolutional Neural Network (CNN) based approach to achieve a very high success rate. It uses YOLO object detector to recognize the license plate data. It is implemented in steps and recognizes the characters from moving vehicles. Bulan et al. [8] uses segmentation and annotation free approach to extract the license plate. It localizes the license plate location in two stages. It uses winnows classifier and CNN in two stages.

Adaptive image segmentation approach [2] proposed by Vassili et al. is much faster than other learning-based approaches. However, its accuracy may suffer in varying illumination condition as it is based on a mean and standard deviation of surrounding intensities. The gradient-based approaches in [3-5] provide very high success rate, but it needs more extended time than conventional segmentation-based methods for processing. This limitation over-shadows its high success rate.

Assumptions made in [6] regarding the presence of a license plate in the lower half of the image may not be valid in practical cases. Methods based on CNN [7] and [8], requires powerful hardware (GPU) support. So, there is a requirement of a method which is invariant to the illumination conditions, orientation and position of the vehicle in an image. Proposed method for license plate recognition discusses these issues. Any license plate recognition system can be explained in two steps:

1. Detection of license plate location
2. Character Segmentation and recognition

This paper discusses the detection of license plate location in great detail in section II. It uses a gradient of the image and thus termed as Gradient Based Segmentation. Method is tested on 78 samples and section III discusses the result obtained. Proposed method performs efficiently in case of wide variation in illumination conditions, orientations and position of license plate in the image. Apart from this, it also handles the damaged license plate effectively. Section IV discusses the pros and cons of proposed method. The algorithm is developed using the OpenCV library and python language.

II. GRADIENT-BASED SEGMENTATION

Gradient-based segmentation uses change in intensity level in the image to determine the location of the license plate. Intensity variation is measured in terms of the gradient of the image. Detection of the boundary between two regions having di□erent intensity levels is considered as edge detection. Boundary detection can be done using first order derivative as well as second order derivative. However, the second-order derivative is very sensitive to noises. Apart from this, the second order derivative also produces a double edge for every transition. Hence, it is not preferred for edge detection. There are two popularly used methods to compute first order derivative:

- Prewitt Edge Operator [9]

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- Sobel Operator [10] and [11]

Sobel operator produces averaging e□ect. As a result, it can be more e□ective against noises in an image. So, proposed method uses the Sobel operator for edge point detection. The magnitude of the edge is further compared with a predefined threshold to avoid unnecessary edges. The whole algorithm is explained as a two-stage problem.

A. Stage 1

Fig. 1 shows the flow chart of stage 1 of the gradient-based segmentation. RGB (Red, Green, Blue) format of the Input image is first converted into HSV (Hue, Saturation, Value) format to perform histogram equalization of Value channel (V) of HSV image. It is performed to compensate for the non-uniform illumination of the image. Since the approach is based on gradients or edges, non-uniform illumination may result in unwanted edges.

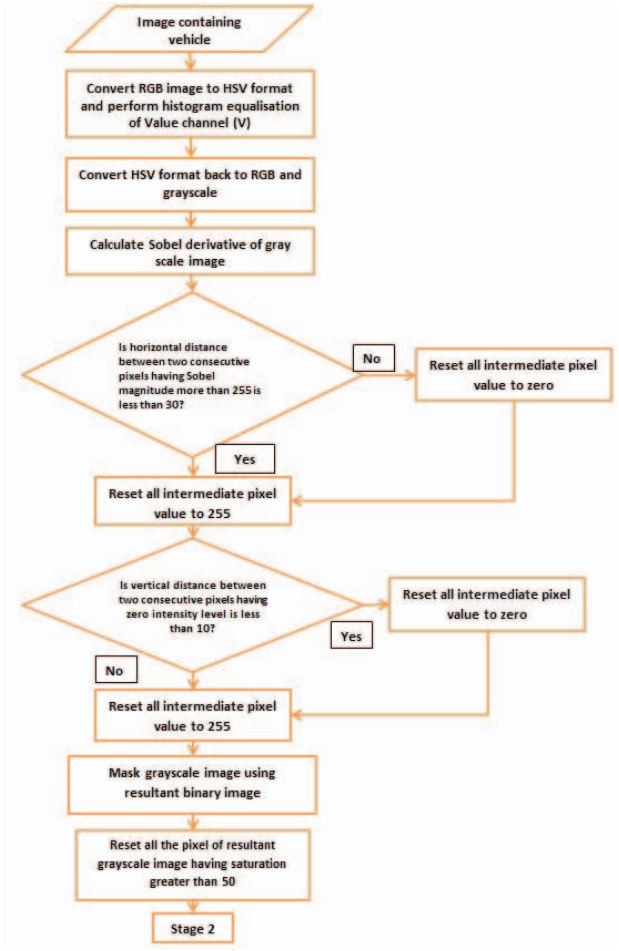

Fig. 1 Flow chart of stage 1 of license plate location recognition

After histogram equalization of Value channel, HSV image is again transformed to RGB and grayscale image. A grayscale image is then operated with Sobel operator-based mask. Sobel operator provides magnitude as well as the angle of edge points. The magnitude of Sobel operator in case of license plate region is usually very high due to very high contrast in the region. So, all the edge points having Sobel magnitude less than 255 are neglected and considered as noise.

In the license plate region, characters are very close in terms of distance. So, all the edge points having a magnitude more than 255 and horizontal distance less than 30 pixels are considered a region of interest. These pixels are updated with a new value of 255 and others are reset to 0.This process is termed as row processing. Once each row is processed, column processing is done on the resultant image. In column processing, it is assumed that character height in license plate is more than 10 pixels. So, if vertical distance between two consecutive pixels with zero intensity is less than 10, then all pixels in the between those pixels are reset to 0 value. Once all columns and rows are processed, it gives a binary image. The binary image is then used as a mask on a grayscale image. Now, again Saturation channel (S) of the original input image is observed, and a mask based on saturation level is created. In this, all the pixels having saturation more significant than 50 is reset to zero. This is used to remove background edge points in a processed grayscale image. After processing with a saturation mask, the masked grayscale image is forwarded to stage 2 of flowchart.

B. Stage 2

Fig. 2 shows the flow chart of stage 1 of the gradient-based segmentation. Stage 2 uses the filter based on aspect ratio and internal contours to extract license plate from leftover contours. A masked grayscale image is binarized at the beginning of stage 2 to extract all the contours.

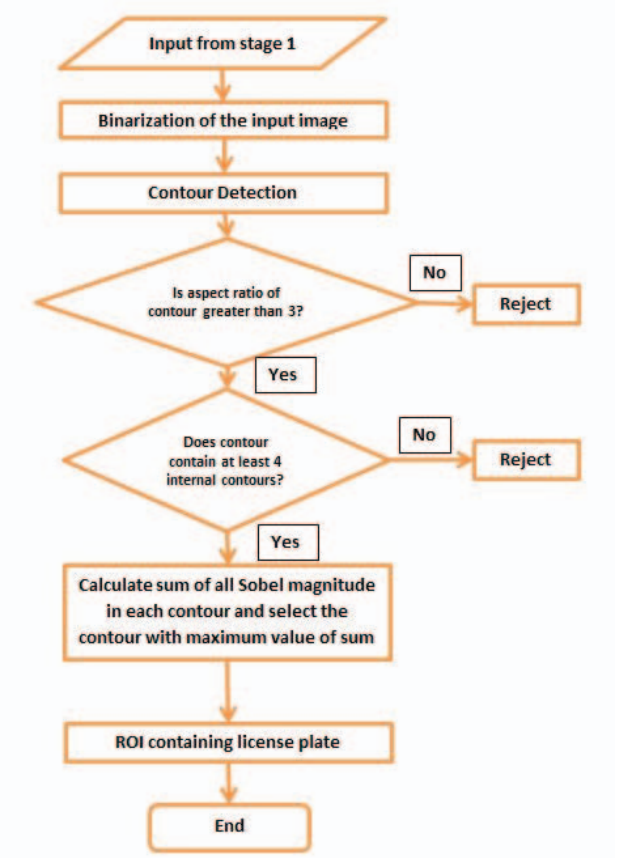

Fig. 2 Flow chart of stage 2 of license plate location recognition

All detected contours are then filtered based on aspect ratio and internal contours. The filter can be explained as:

1. **Aspect ratio > 3** Generally aspect ratio of the license plate is more than 3 in India. So, all contours having an aspect ratio less than three are rejected.
2. **Internal Contour > 4** License plate in India contains 9 or 10 characters. However, there can be some instances when all characters will not be readable in the license plate. So, an assumption is made that a contour must contain at least four internal contours or characters to be qualified as a probable candidate for license plate location.

The proposed method is based on high and frequent contrast variation in the license plate. The magnitude of Sobel operator is very high in license plate due to very high contrast in the region. So, the contour having a maximum value of some of the Sobel magnitude inside the contour is considered as license plate region.

III. RESULT

In order to justify the acceptability, the method was applied on 78 images taken in di□erent conditions in the campus of Indian Institute of Engineering Science and Technology, Shibpur. Images are taken on 12 MP camera of Xiaomi Redmi Note 5 Pro. It generates 74 positive results. The output of each process discussed in the previous section is explained here for one test image.

Fig. 3.a

Fig. 3.b

Fig. 3.a Original input image containing vehicle
Fig. 3.b Sobel operator output of input image

Fig. 3.b shows the Sobel operator output of the input image shown in Fig. 3.a. Sobel operator gives thick edges, unlike the Laplacian operator. However, in this approach Sobel derivative is not used for edge detection directly. It is used to get the edge points shown here.

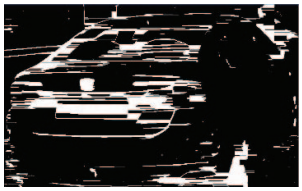

Fig. 4.a

Fig. 4.b

Fig. 4.a Image after row processing
Fig. 4.b image after column processing

Fig. 4.a shows the image after row processing. All the white pixels are considered a region of interest. It can be observed that apart from the license plate there are lots of regions which is considered a region of interest. Column processing filters most of the unwanted region obtained from row processing. Fig. 4.b shows output after column processing. License plate region can easily be observed from the image. However, there are still some unwanted regions that can create problem while detecting the required region. Image obtained from the column processing step can be used as a mask.

Fig. 5.a

Fig. 5.b

Fig. 5.a Masked grayscale image
Fig. 5.b Grayscale image after masking with saturation mask and mask obtained after column processing

Fig. 5.a shows a grayscale image after masking it with Fig. 4.b. It can be observed that apart from the license plate region, there are still some unwanted regions. These regions can be reduced after saturation masking. Fig. 5.b shows the result after saturation masking. It can be observed that certain regions like tail lights are masked in this step.

Fig. 6 Image showing License Plate region obtained after final filter

Fig. 6 shows the image containing the final contour obtained after applying all filters. It can be observed that the contour obtained after applying all filters is the license plate region.

IV. DISCUSSION

The proposed method provides high accuracy in a wide range of imaging condition. Test images are shown in fig. 7 and 8 further rea□rm the fact that it can handle a wide range of variation. Vehicle in fig. 7 shows its ability to handle images taken in shades or low illumination.

Fig. 7 The image was taken in the shade or low illumination and extracted license plate

Fig 8.a shows that the method is not only resistant towards the presence of a license plate in any part of the image but can also handle a wide variation of orientation.

Fig. 8.a

Fig. 4.b

Fig. 8.a Di□erently oriented license plate extraction
Fig. 8.b Extraction of damaged or noisy license plate

Many a time, license plate recognition techniques are designed to extract the license plate from either front or back view of the vehicle. However, this method can be applied to the front or back view of the images. In fig 8.b license plate is damaged and contains noises in the form of dirt. Methods which are sensitive towards noise may fail to process such samples to extract license plate successfully. Histogram equalization mentioned in flow chart given by fig. 1 is one of the most critical factors for high accuracy of the method. Without histogram equalization method's accuracy reduces from 94.87% to 80.76%.

Fig. 9 Vehicle whose license plate could not be extracted

Fig 9 shows the images which could not be processed successfully to extract the license plate region using a derivative-based method. On analyzing the failed samples, it can be concluded that the method struggles to provide excellent result if license plate contains two rows. While developing a gradient-based segmentation method, it was assumed that license plate consists of a white base with black characters. So, saturation masking was used to filter out any leftover region in the image containing any shades of hue. However, in India, most of the rental vehicle's license plate consists of a yellow base. In such cases, the method fails to provide a favorable result. Failed samples in fig 9 also justify the same. This can be overcome by excluding the yellow color channel from saturation masking. In the derivative-based method, the license plate region is obtained by calculating the sum of all Sobel operator magnitude in each leftover contour at the end. The contour which provides maximum value of the sum of magnitude is considered as the license plate. Because of this approach, it cannot process two vehicles simultaneously present in a single image and will provide only one license plate information.

V. Conclusion

Proposed techniques can be e□ectively applied for license plate location tracking irrespective of the location of the vehicle in the frame. It provides high accuracy even during the wide variation in imaging condition. It is based on image segmentation and does not involve any machine learning tool. Hence, it is much faster and easier to implement. It can also handle differently oriented samples effectively and shows the accuracy of 94.87% when tested on a wide range of test samples. Though it failed to extract the license plate with a yellow base, it can be overcome by adopting the suggested measures. This paper discusses one aspect of license plate recognition, i.e. detection of license plate location. However, it can be incorporate with any character segmentation and recognition technique to achieve the objective of license plate recognition.

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