# Vehicle License Plate Recognition System Using LoG Operator for Edge Detection and Radon Transform for Slant Correction

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**Abstract: Vehicle license plate recognition system is an image processing technique in which images of cars (moving or still) are processed and the license plate number is extracted. In today's world, Vehicle License Plate Recognition finds use in various situations like vehicle surveillance at the roads and traffic lights, at official building parking lots, for security purposes, etc. Various algorithms have been developed over the years for recognizing license plate characters efficiently. This paper proposes an algorithm that uses Laplace of Gaussian operator to find out edges in the image of car showing the license plate and correlation with the templates of characters to recognize the text in the license plate. It also corrects tilt in the images, if any. This algorithm has been tested on more than 400 images (with and without tilt) and it has been shown than even with a lot of variations in the lighting and clarity of the image this algorithm achieves 98% efficiency in successfully segmenting the license plates.**

**Keywords: License plate recognition, edge detection, character recognition, tilt correction, parking lot automation, morphological operation.**

## I. INTRODUCTION

In Vehicle Number Plate Detection, local variations in geometry, intensity and statistical properties are used to locate the license plate in an image of the car. In India there are different types of license plates in terms of color, size, number of rows of characters present and the types of font used. These unpredictable variations make it very difficult to make a generalized system that can cope with all of them. The objective of this project is to design a system which is capable of extracting the number plate region from the vehicle's image dealing with some of the above mentioned variations and returning the license plate number. The algorithm proposed in this paper is a novel and very robust algorithm with variations in the image properties including rotation caused due to the relative angle between the car and camera. This algorithm uses still images of cars for testing which can be a case in parking lots, toll plaza etc. some cases that caused failure were, segmentation in cars with number plate very similar to the background, the diversity of the number plate characteristics like different fonts and designs used in it. The Vehicle License Plate Detection system can be divided into six modules:

 a. Image acquisition
 b. Image preprocessing
 c. Edge detection and Tilt correction
 d. License Plate segmentation
 e. Character segmentation
 f. Character recognition

The rest of this report is organized as follows. The next section (Section II) composes a review of similar research that have been implemented and tested for vehicle license plate recognition. Section III explains the proposed algorithm and each module in it, in detail. Section IV lists the results obtained by the proposed algorithm and example images and Section V concludes the paper with some discussion of future work.

## II. SIMILAR RESEARCH

Vehicle license plate detection and recognition has been studied and researched by many people over many years now. The aim has always been to develop an algorithm that can successfully extract the license plate of varying sizes, images having variations in lighting conditions and designs and characters of different font in the plate. A survey shows the research done in this area [1]. Work has been done in license plate segmentation in which the selection of the license plate is based on its color [10], but the drawback in this is the inability of the algorithm to locate the license plate when the car color is the same as license plate color or there are other locations with similar color. SCW based license plate localization [2], [3] has been used frequently. Another method is by using wavelet transform along with a window approach to locate the license plate [4]. Using morphological filters for edge detection and license plate localization is one of the most studies methods [5], [7], [8], [11], [12]. Sobel based edge detection methods are also used frequently [9], [13]. Another innovative method is using position histograms to locate the license plate without any edge detection [6].

## III. PROPOSED ALGORITHM

The modules of the proposed algorithms are as summarized in introduction. Our algorithm uses Laplacian of Gaussian (LoG) filter for edge detection. Laplacian filters (equation 1) are derivative filters used to find areas of rapid change (edges) in images. They are prone to noise and hence to remove noise, another Gaussian filtering step is added. This two-step process is called the Laplacian of Gaussian (LoG) operation.

$$L(x,y) = \nabla^2 f(x,y) = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2} \quad (1)$$

There are different ways to find an approximate discrete convolution kernel that approximates the effect of the

Laplacian. Laplace and Gaussian functions are combined to obtain a single equation (equation 2).

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right]e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (2)$$

A discrete kernel for the case of σ = 1.4 is given by

$$\begin{pmatrix}
0 & 0 & 3 & 2 & 2 & 2 & 3 & 0 & 0 \\
0 & 2 & 3 & 5 & 5 & 5 & 3 & 2 & 0 \\
3 & 3 & 5 & 3 & 0 & 3 & 5 & 3 & 3 \\
2 & 5 & 3 & -12 & -23 & -12 & 3 & 5 & 2 \\
2 & 5 & 0 & -23 & -40 & -23 & 0 & 5 & 2 \\
2 & 5 & 3 & -12 & -23 & -12 & 3 & 5 & 2 \\
3 & 3 & 5 & 3 & 0 & 3 & 5 & 3 & 3 \\
0 & 2 & 3 & 5 & 5 & 5 & 3 & 2 & 0 \\
0 & 0 & 3 & 2 & 2 & 2 & 3 & 0 & 0
\end{pmatrix}$$

The LoG operator takes the second derivative of the image and returns a zero value wherever there is uniformity in the image and a positive or a negative response for the changes.

a.  Image Acquisition:
Image acquisition is achieved using a camera with a decent resolution and lighting (Fig. 1).

b.  Image Preprocessing:
Input RGB image is converted to gray-scale and will be used for further processing. This conversion is done using the following relation

$$0.2989 * R + 0.5870 * G + 0.1140 * B \quad (3)$$

where, R, G and B are the red, green and blue components of the image (Fig. 2).



**Fig. 1: Original RGB image**



**Fig. 2: Image converted to gray-scale**

c.  Edge detection and Tilt correction :
The LoG operator is used for edge detection and returns a gray-scale image which is then converted to binary (Fig. 3). Sometimes due to the camera orientation or the location of the car, acquired images might get tilted. With such images license plate recognition becomes difficult because the geometry is changed, which plays a major role in the segmentation. To correct the tilt and continue with the processing for license plate recognition and segmentation, Radon transform is employed in this algorithm which computes the line integrals from different angles by rotating the source around the center of the image. This transform is applied to the edge image in Fig. 3. Assuming that an image of a car has more horizontal edges than vertical we get the orientation of the horizontal edges of the image with respect to horizontal axis. Fig. 4 shows the radon transform of the edge image at angles ranging from 0 to 179 degrees. The angle which has the most number of peak values is extracted from the result (θ degrees). Now the image was rotated anti-clockwise by angle (90- θ) (Fig. 5). This binary image is then dilated (Fig. 6(a)). Dilation is a morphological operation performed to fill up the gaps in the edges around the license plate, if any. Now, the dilated image is inverted (Fig. 6(b)) to make the license plate surrounded by a black border. The areas bigger than 20000 pixels were removed from the image (Fig. 7) considering that the license plate cannot be that big with the distance between the camera and car being 1-7mtrs and further processing is continued for the license plate extraction.
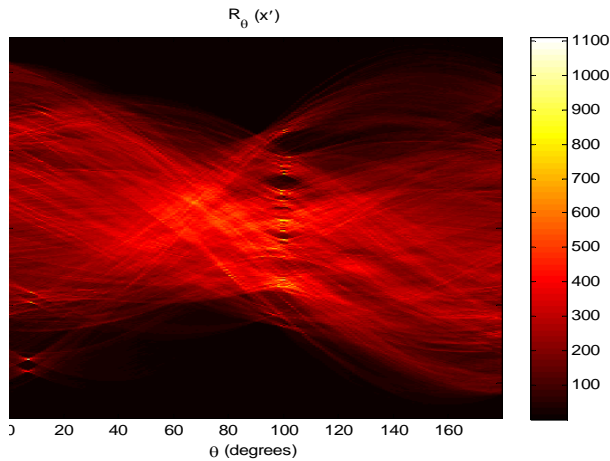


(a)



(b)

**Fig. 3: (a) Gray-scale edge image, (b) Binary edge image**

Fig. 4: Radon transform of the image in figure 3

a.  License plate extraction:

After the above processing, a connected components analysis is done on the image. It is a technique in image processing that scans an image and labels its pixels into components based on pixel connectivity.

This analysis gives us row extremities and column extremities within which the component is present.

From these coordinates, corresponding sub-images



(a)
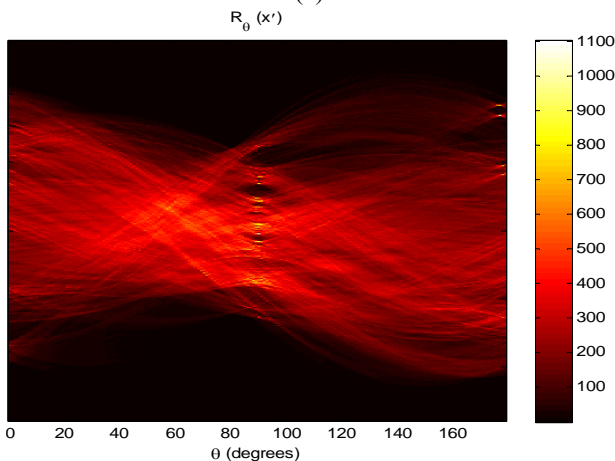


(b)

Fig. 5: (a) Rotated gray-scale image, (b) Radon transform of the rotated image



(a)



(b)

Fig. 6: (a) Dilated image, (b) Inverted image



Fig. 7: Big and unwanted areas removed

are obtained from the gray-scale image. These sub-images are then converted to binary and inverted so that if it is the license plate, the characters are converted to white and another connected components analysis could be performed on it. Geometrical and statistical properties of the license plate are used for detection and extraction. The aspect ratio is the ratio of width to height of the sub-image, which can be computed using

$$ ar = \frac{(C_{max} - C_{min}) + 1}{(R_{max} - R_{min}) + 1} \qquad (4) $$

where, $C_{max}$ , $C_{min}$ , $R_{max}$ and $R_{min}$ are the column and row extremities respectively. The images acquired for this project have license plates with aspect ratio varying as $1.5 < ar < 6$ (license plates with two rows have a lower aspect ratio than the ones with a single row). Hence, this was used as a criterion for the license plate extraction. More criteria for selection were used to improve the performance. Only

those sub-images that have more than 5 connected components (as there should be characters present for it to be a license plate) were considered to be a probable license plate. Finally, the width of the sub-image was to be greater than 1/15th of width of the image. From the probable license plate sub-images, the final license plate was chosen to be the one having maximum standard deviation (Fig. 8).

b.  Character segmentation:

For character segmentation, some processing is done on the license plate that was extracted from the gray scale image, so that the unwanted (non-character) components can be removed. First, the license plate is binarized and inverted (inversion is done to make the characters white since the template characters are that way). After inversion the border elements and components less than 120 pixels are removed. Objects having height less than 80% of the average height of the components in the license plate are removed from the image (Fig. 9).


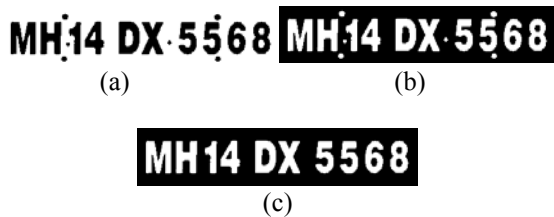
**Fig. 8: Extracted license plate**



**Fig. 9: (a) Binarized License plate, (b) Inverted image, (c) Unwanted areas removed**

We use position histogram to segment the rows for plates with more than one row and crop empty areas above and below the characters in the license plate. This histogram represents a row-wise sum of binary values. In case of two rows, the second row is selected for character extraction only if it is greater than 1/3 the size of the first row selected and has a mean value more than 70% of mean of the histogram. The bounding box technique was used to get the coordinates of the smallest rectangle surrounding the characters. From these details, the characters were cropped out of the license plate easily (Fig. 10). Fig. 11 shows the same procedure in case of two rows.
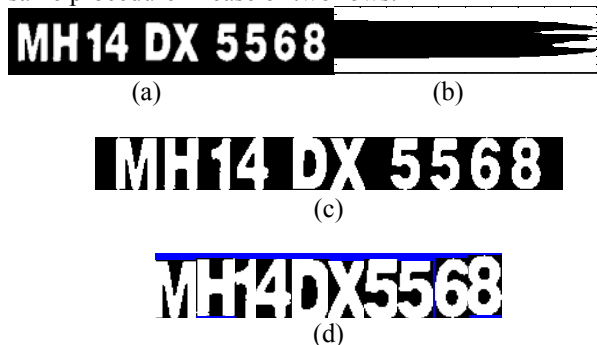


**Fig. 10: (a) Binarized License plate, (b) Vertical histogram, (c) Cropped row, (d) Segmented characters**
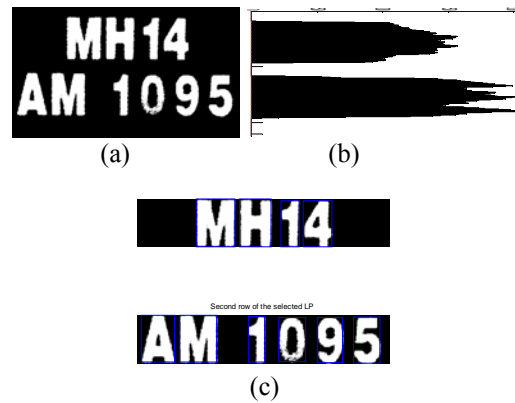


**Fig. 11: (a) Binarized License plate, (b) Vertical histogram, (c) Cropped row and segmented characters**

c.  Character recognition

Once the characters were segmented, they were resized to the size of the characters in the template. They were then matched with the templates one by one and the correlation was computed. The maximum correlation pair was selected and based on which character was from the template, the results were obtained. In this case the returned license plate number was: MH14DX5568.

## IV. EXPERIMENTAL RESULTS

For our algorithm, more than 400 images are used with different lighting conditions, resolutions and different fonts. Distance between the camera and car is varied from 1 to 7 m. A 13x13 Laplacian mask is used for edge detection, along with a Gaussian filter with sigma = 3. The algorithm is very fast and is able to successfully segment 98% license plates. Character recognition was able to read 90% of the license plate characters.

## V. CONCLUSION AND FUTURE WORK

The proposed algorithm is very fast as compared to the other widely used algorithms and is very efficient in locating and segmenting the license plate in a variety of images having a range of sizes of license plates. The mistakes in character recognition were due to the presence of different kind of fonts in the license plate and the clarity of the characters. Further study can include exploring neural network for character recognition and adding more fonts to the database for more efficient recognition.

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