Comparison of Edge Detection Techniques for Segmenting Car License Plates

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ABSTRACT
This paper deals with the study of different edge detection techniques for plate localization component of a Car License Plate Recognition system. The process of edge detection also involves filtering and smoothing of image. An experimental study has been carried out in this paper for comparison of the available edge detection techniques for this emerging area of application. Single frame gray-level images are used as the only source of information. In the experiment images of Indian license plates were used, which are taken with the Kodak camera 10Mpixels. The results show that the approach is robust to illumination, plate slope, scale, and is insensitive to plate's country peculiarities. These results could be also usable for other applications in the input-output transport systems, where automatic recognition of registration plates, shields, signs, etc., is often necessary.

Keywords
Edges, Car license plates, Image processing, Segmentation and Recognition.

1. INTRODUCTION
With the rapid development of highway and the wide use of vehicle, more attention is being paid on the advanced, efficient and accurate intelligent transportation systems. Vehicle identification has hence become important in the field of computer vision. Vehicle License Plate Recognition (LPR) has become an important application in the transportation system. It applies image processing and character recognition technology to identify vehicles by automatically reading their license plates. It can be used in many applications such as entrance admission, security, parking control, road traffic control and speed control. Through number of survey reports, it is clear that a number of commercial software are available in this area but none of these give good results if vehicle image has different styles of characters, different backgrounds and formats. Also most of these presume some constraint about the standard characters, standard formats of License Plate, location of the camera, distance from the camera and inclination angle etc. [1, 2].

The focus of this paper is on the selection of suitable edge detection technique for a good Automatic License Plate Detection and Recognition System. This paper has been divided in to five sections. After introduction, section 2 presents the state of art in this field. A description of system model for License Plate Extraction is given in section 3. The experimental results are shown in the section 4. The next describes the conclusion drawn from this paper on the basis of results obtained from the experiments.

2. STATE OF ART
In the field of car license plate extraction and recognition has picked up speed in the recent years. Some of the related work is as follows. Lotufo et. al. [3] have proposed automatic number plate recognition using optical character recognition techniques. Jonson and Bird [4] have used knowledge guided boundary following and template matching for automatic vehicle identification. Use of bidirectional associative memories (BAM) neural network for number plate reading has been made by Fahmy [5]. Yoshimura and Etoh [6] have used Gabor jets projection to form a feature vector for recognizing low resolution gray-scale character. Hontani et. al. [7] have proposed a method for extracting characters without prior knowledge of their position and size in the image. Park et. al. [8] have devised a method to extract Korean license plate depending on the color of the plate. Kim et. al. [9] have used a method of extracting plate region based on color image segmentation by distributed genetic. In 1999 Sirithinaphong T. and Chamnongthai K. [10] have proposed the recognition of car license plate which is accurate and robust to environmental variation by using the car's license plate patterns according to motor vehicle regulation and a 4-layer BP neural network with supervised learning. The performance of his car license plate extraction system was 96%, and the recognition rate was 92%.

In 2010, Lihong et. al. [11] have invented a new system for Automatic License Plate Recognition. It is useful for real time traffic management and surveillance. This paper presents an efficient algorithm for non character area removal. The algorithm is based on the license plates detected using an AdaBoost algorithm. Then it follows the steps of character height estimation, character width estimation, segmentation and block identification. The algorithm is efficient and can be applied in real-time applications. The experiments are performed using OCR software for character recognition. It has been shown that much higher recognition accuracy is obtained by gradually removing the license plate boundaries.

3. MODEL FOR LICENSE PLATE EXTRACTION

License plate recognition usually contains two steps, namely license plate detection/localization and character recognition. Recognizing characters in a license plate is a very difficult task due to poor illumination conditions and rapid motion of vehicles. When using an OCR for character recognition, it is crucial to correctly remove the license plate boundaries after the step for license plate detection. No matter which OCRs are used, the recognition accuracy will be significantly reduced if the boundaries are not properly removed.

The main goal of this research paper is to find better edge detection technique to implement an efficient method to recognizing license plates in Indian conditions because in Indian scenario vehicles sometimes carry extra information such as owner's name, symbols, design along with different standardization of license plate etc.

An overview of the proposed License Plate Segmentation system can be seen in Figure 1. After the vehicle image is captured by the camera, it will be passed through the preprocessing unit which process the image captured by the camera. The main operation is to suppress the noise and enhance the image features. So the plate can be segmented properly. The next phase is responsible to segment the individual character. Finally, each character will pass through Optical Character Recognition [11].

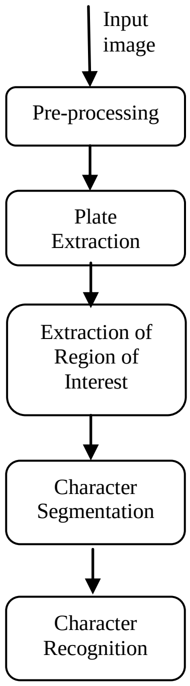

Figure 1. License Plate Recognition Model

3.1 Pre-processing

Preprocessing is necessary to facilitate further high performance recognition. In this study, the RGB color input image is converted to a 256 grayscale image using NTSC standard [1] is given in Equation 1.

$$Gray = 0.299*Red+0.587*Green+0.114*Blue \qquad \ldots\ldots\ldots\ldots(1)$$

Then a median filter (5x5) is applied to the gray level image to remove the noise, while preserving the sharpness of the image.

3.2 Plate Extraction

For the correct license plate detection/extraction, identification of edges is very important as it consists of edges of definite size and shape. In blurred images identification of edges is difficult and requires sharpening of the edges. So it is desired to select a proper filter to filter the edges of the license plate.

The standard Indian License Plate consists of a row of black characters on white background, it means the license plate is characterized by a row of transition for white to black and again black to white, such transition are called as "edges". The total change in intensity from plate's characters to its background is called the strength of the edge. The stronger edge can be found in case of a transition from a white pixel to black pixel or black to white pixel. There are a number of edge detection filters available. Out of these following three filters have been tested for this model:

1). Prewitt's mask
2). Sobel's mask
3). Canny's mask.

The masks used for the first two of the three selected techniques are shown in Figure 2, followed by a description of the method used to obtain Canny's mask.

-1	-1	-1
0	0	0
1	1	1

(a)

-1	0	1
-1	0	1
-1	0	1

(b)

-1	-2	-1
0	0	0
1	2	1

(c)

-1	0	1
-2	0	2
-1	0	1

(d)

Figure 2 Prewitt's Masks (a) Horizontal (b) Vertical Sobel's masks (c) Horizontal (d) Vertical

The 3x3 Prewitt's masks are simpler to implement than 3x3 Sobel's masks, but, the slight computational difference between them is typically not an issue. Sobel's operator performs a 2D spatial gradient measurement on an image. Typically it is used to find the approximate gradient magnitude at each point in the input gray scale image. The Prewitt's and Sobel's masks are as follows [12].

Although Canny's algorithm is more complex, the performance of the Canny edge detector is superior than others. Canny's approach is based on three basic objectives: low error rate, localized edge points, and single edge point response [12].

In order to implement the Canny's edge detector algorithm the first step is to filter out any noise in the original image before trying to locate and detect any edges. Since Gaussian filter can be computed for $\sigma = 1.4$ using a simple mask, it is used exclusively in the Canny algorithm.

$$\frac{1}{115}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

An edge in an image may point in a variety of directions, so the Canny's algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image. The edge detection operator (Roberts, Prewitt, Sobel for example) returns a value for the first derivative in the horizontal direction (Gy) and the vertical direction (Gx). From this the edge gradient and direction can be determined:

$$G = \sqrt{G_x^{\,2} + G_y^{\,2}}$$

$$\theta = \tan^{-1}\left(\frac{G_y}{G_x}\right)$$

The edge direction angle is rounded to one of four angles representing vertical, horizontal and the two diagonals (0, 45, 90 and 135 degrees for example).

The magnitude or edge strength of the gradient is then approximated using the formula:

$|G| = |Gx| + |Gy|$

Once the edge direction is known, the next step is to relate the edge direction to a direction that can be traced in an image. So if the pixels of a 5x5 image are aligned as follows:

x	x	x	x	x
x	x	x	x	x
x	x	a	x	x
x	x	x	x	x
x	x	x	x	x

Then, it can be seen by looking at pixel "a", there are only four possible directions when describing the surrounding pixels - 0 degrees (in the horizontal direction), 45 degrees (along the positive diagonal), 90 degrees (in the vertical direction), or 135 degrees (along the negative diagonal). So now the edge orientation has to be resolved into one of these four directions depending on which direction it is closest.

Though it is a superior mask, it detects even very small changes in the intensities. Due to this, it is not preferred for License Plate Detection.
Thus, the remaining techniques are Prewitt's and Sobel's masks but due to better noise suppression quality of Sobel's mask, it has been found to be the most useful for License Plate Recognition Techniques.

3.3 Extraction of Region of Interest

After creating the edge image, the system will search for regions with high edge values which are most likely to contain a license plate. To do so the system will construct a horizontal and vertical projection profile of the edge image. A horizontal projection profile is defined as the vector of the sum of the pixel intensities over each row. The peaks in the histogram indicate the regions with strong edges and can be used for horizontal position of the license plate. The next step in the plate extraction process is to find the vertical position of the license plate. For this histogram of 30 different license plates were checked and then selected the threshold values. But the results were not satisfactory for different types of characters. Through a simple Horizontal Density Vector (HDV), it can be located easily with the edge images. It can be calculated as

$$HDV(i) = \frac{\sum_{x\in W}\sum_{y\in W} G(x,y)}{A_w}$$

where i=0,1,2……(lmW-M+1), G(x,y) is the edge image, W is the sliding window, A_w is the area of the sliding window. ImW is the width of image and M is the width of sliding window [1, 14].

3.4 Character Segmentation

After Plate Extraction the next step is Character segmentation. It is an important stage in many license plate recognition systems. There are many factors that make the character segmentation task difficult, such as image noise, plate frame, rivet, and rotation and illumination variance. Preprocessing is very important for ensuring the good performance of character segmentation. But in License Plate Recognition System it is not required because it is already been removed.

To ease the process of identification, it is preferable to divide the extracted plate into different images, each contains one isolated character. The following steps are used to segment the character:

1. Stretch the contrast of the image to extend over the entire range of gray levels available.
2. Threshold the plate image
3. Search for the connected components in the image, each connected component will be assigned a special label in order to distinguish between different connected components.

The character is resized to the standard height and width (20x10) in order to be used for recognition system.

3.5 Character Recognition

Before employment of the recognition algorithm, the characters should be normalized. Normalization refines the characters into a block containing no extra white spaces (pixels) in all the borders of the characters. Then each character is fit to a 20x10 block. Fitting is necessary for template matching. For matching the characters with the database, input images must be equalized to a 20x10 block with the database characters [14].

The extracted characters cut from plate and the characters on database are now equalized. The next step is template matching. Template matching is an effective algorithm for recognition of characters. The characters' image is compared to the ones in the database and the best similarity is considered. To measure the similarity and find the best match, a statistical method based on correlation is used. Correlation is an effective technique for image recognition. This method measures the correlation coefficient between a number of known images with the same size unknown images or parts of an image with the highest correlation coefficient between the images producing the best match.

4. Experimental Results

Experiments have been performed to apply the proposed scheme and compare the suitability of edge detection techniques. The system is simulated in the MATLAB 2009a for the recognition of Indian License Plate. A set of 30 different images with various angles and various directions (Front and Back) captured during the day hours, were used to testing. three different techniques Prewitt's mask, Sobel's mask and Canny's mask were used for the edge detection. An example of the original photograph of the back side of a car showing its number plate and the edge detection results obtained after the application of the three selected masks have been shown in Figure 3. The difference in the outputs obtained after the application of the selected techniques is clearly visible.

The summary of experimental results as shown in Table 1 clearly indicates that Sobel's mask is the most suitable for Edge Detection for Automatic License Plate Recognition System.

Table 1. Experimental Results

No. of Number Plates (30)	Prewitt's Mask	Sobel's Mask	Canny's Mask
Proper Recognition	26	29	23
% Recognition	86.67	96.67	76.66

(a)

(b)

(c)

(d)

Figure 3 Simulation Results: (a) Original Image (b) Output after applying Prewitt's Mask (c) Output after applying Sobel's Mask (d) Output after applying Canny's Mask.

5. Conclusion

This paper presents a comparison of techniques for edge detection for identifying and recognizing Indian car license plates. The purpose is to investigate the goodness of edge detection techniques for developing an Automatic Recognition system for License plates. The results clearly indicate that Sobel's Mask is the most suitable mask for the License Recognition System. Further it has been found that for good recognition, Back Number Plate should be preferred to the Front Number Plate.

6. References

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