Indian License Plate Detection and Recognition Using Morphological Operation and Template Matching

W. Devapriya, C. Nelson Kennedy Babu, T. Srihari

Abstract—Automatic License plate recognition (ALPR) is a technology which recognizes the registration plate or number plate or License plate of a vehicle. In this paper, an Indian vehicle number plate is mined and the characters are predicted in efficient manner. ALPR involves four major technique i) Pre-processing ii) License Plate Location Identification iii) Individual Character Segmentation iv) Character Recognition. The opening phase, named pre-processing helps to remove noises and enhances the quality of the image using the conception of Morphological Operation and Image subtraction. The second phase, the most puzzling stage ascertain the location of license plate using the protocol Canny Edge detection, dilation and erosion. In the third phase, each characters characterized by Connected Component Approach (CCA) and in the ending phase, each segmented characters are conceptualized using cross correlation template matching- a scheme specifically appropriate for fixed format. Major application of ALPR is Tolling collection, Border Control, Parking, Stolen cars, Enforcement, Access Control, Traffic control. The database consists of 500 car images taken under dissimilar lighting condition is used. The efficiency of the system is 97%. Our future focus is Indian Vehicle License Plate Validation (Whether License plate of a vehicle is as per Road transport and highway standard)

Keywords—Automatic License plate recognition, Character recognition, Number plate Recognition, Template matching, morphological operation, canny edge detection.

I. INTRODUCTION

IN India the license plate number is issued by the district-level Regional Transport Office (RTO) of respective states. The plate must be placed in front and rear of the vehicle. On the basis of the recommendations made by the Technical Standing Committee on Central Motor Vehicles Rules, the Central Government had amended rule 50 of the Central Motor Vehicles Rules, 1989, mandating introduction of new High Security Registration Plates, both in respect of new and in-use motor vehicles throughout the country. A sample format for high security registration plate [16] is shown in Fig. 1. The Features of High Security Registration Plates are

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Chromium hologram, a retro-reflective film, bearing a verification inscription 'India' at 45 degree inclination. Laser numbering, which is unique in nature containing alpha-numeric identification of both Testing Agencies and the manufacturers. The Registration numbers to be embossed on the plates. In case of rear registration plate, same to be fitted with a non-reusable snap lock to make it tamper proof.
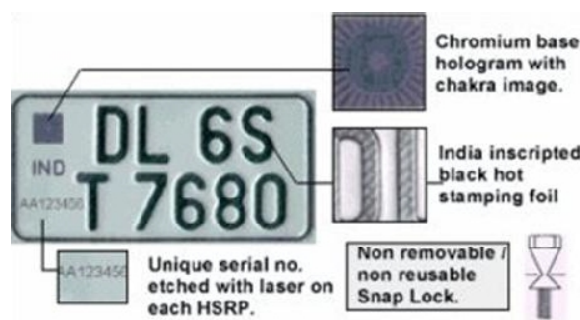

Fig.1 High Security Registration Plates Image

A Chromium based third registration plate in the form of sticker is to be attached to the wind shield, wherein the number of engine and chassis are indicated along with the name of registering authority. If tampered with, it self-destructs. In front and rear registration plates, letter IND in blue color is hot stamped. Letters 'IND' written in blue color is located on extreme left center of the plates [12].

The fonts are mandatorily to be written only using modern Hindu-Arabic numerals with Latin letters. The license plate consists of 3 parts; i) First two letters indicate the state to which the vehicle is registered. ii) Next two digit numbers are the sequential number of a district. iii) The third part is a 4 digit number unique to each vehicle plate. A letter(s) is prefixed when the 4 digit number runs out and then two letters and so on. The image shown below is the format for license plate. The plates will be highly secure with "lock, hologram and unique numbers. Fig. 2 is a sample number plate figure in which

- TN – Tamil Nadu
- 28 – Namakkal District code in Tamil Nadu
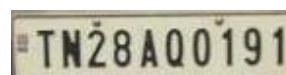- AQ 0191 –unique serial code for that particular vehicle.

Fig. 2 Sample License plate

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II. FLOWCHART OF PROPOSED METHODOLOGY

Automatic License Plate Recognition (ALPR) is very important part of Intelligent Transportation System (ITS). Usually, an ALPR system consists of four major process i) Pre-processing ii) License Plate Location Identification iii) Individual Character Segmentation iv) Character Recognition [1], [3], [8], [10]. The first stage, called pre-processing helps to improve the image information and removes unwanted noise. Second stage, the most challenging stage is to identify the location of license plate, which directly affects system's overall performance. In third stage, characters are separated using segmentation process and in the final stage segmented characters are recognized [6], [7]. License plate recognition are implemented using histogramming and mathematical morphology, vertical edge detection and mathematical morphology techniques, hat transform and morphological operations, morphology and auto–correlation, horizontal gradient and morphological operation, edge finding and window method, line detection etc.
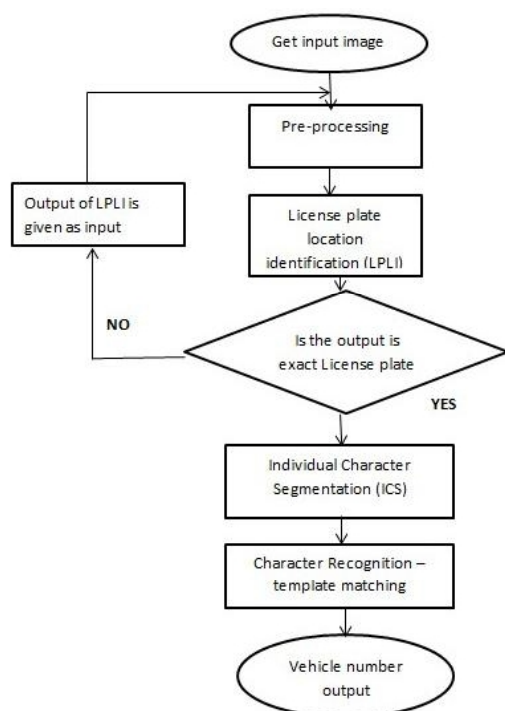

Fig. 3 Flowchart of the Proposed System

This paper proposed a methodology for the Indian license plate location. The rest of the paper is organized as follows: Section III describes the pre-processing, Section IV describes the license plate location identification, Section V describes individual character segmentation, and Section VI describes License Plate Character Recognition Using Template Matching Approach, section VII Experimental results, Section VIII conclusions, and last are acknowledgements and references.

III. PRE-PROCESSING

Image pre-processing is the technique for improving the image information that removes unwanted data, noise, and distortion in the image and enhance image data prior to computational processing [12]. Fig. 4 shows the flow of operation inside preprocessing.
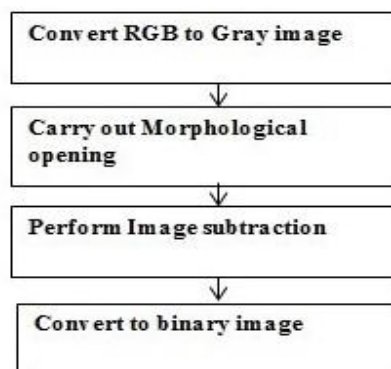

Fig. 4 Pre-processing flow of operation

A. Conversion of RGB Image to Grayscale Image

An RGB image is altered to gray scale image by using three different methodologies namely lightness, average, and luminosity. Luminosity method is the refined version of the average method. Human eyes are more sensitive to green color than red and blue color so green is assumed high value and the formula for computing luminosity as in (1),

$$L(x, y) = 0.21 R(x, y) + 0.72 G(x, y) + 0.07 B(x, y) \quad (1)$$

where R – Red component of the image; G – Green Component of the image; B – Blue component of the image; x, y – position of a pixel.

Fig. 5 Sample input car image

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The main plus point of this conversion is to reduce the computational complexity. The input RGB image is shown in Fig. 5 and the gray scale image is shown in Fig. 6 (a).

B. Morphological Opening

Morphological operation [9], [14] depend only on relative ordering of pixel values, not on their numerical values, and therefore are mainly appropriate to the processing of binary images. We can apply morphological operations on gray scale image also. Morphological opening is type of morphological operation in which structures that are smaller in shape will disappear and structures larger in shape will remain in foreground with respect to the structure element B. The structure element must come along with a shape and size in our proposed work the structure element size is 25 and shape is disk. The opening of A by B is achieved by the erosion of A by B, tailed by dilation by B as in (2)

$$A \circ B = (A \ominus B) \oplus B \qquad (2)$$

where A - Input gray scale image; B - Structure element; $\circ$ - Opening notation; $\ominus$ - Erosion notation; $\oplus$ - Dilation notation. The output image after performing the morphological opening is shown in Fig. 6 (b).

C. Image Subtraction

The Image pixel subtraction operator receives two input images and produces a third image at output. The subtracted pixel value of the image is the first image pixel value minus the second image pixel value at corresponding pixel position. The subtraction is done between the gray image and morphological opened gray scale image. Some versions of the operator will just output the absolute difference between pixel values, rather than the straightforward signed output as in (3)

$$S(i, j) = P(i, j) - Q(i, j) \qquad (3)$$

where P (i,j) and Q (i,j) are the input image and S (i,j) is the subtracted output image. The subtracted image is exposed in Fig. 6 (c).

D. Convert the Result to Binary Image

This process converts the grayscale image to a binary image. The output image substitutes all pixels in the input image with luminance higher than the threshold with the value 1 (white) and substitutes all other pixels with the value 0 (black). The threshold is compute by using the formula

Thres = (fmax1 - (fmax1 -fmin1)/2)/225
Where fmax1 = double (max (max (d))),
fmin1 = double (min (min (d))) and
d – Result of subtracted image.

The default threshold value is 0.5. The subtracted image is converted to binary image using the following matlab command. Computing threshold value is good practice since it depends on the input image taken. The result of this conversion is shown in Fig. 6 (d).
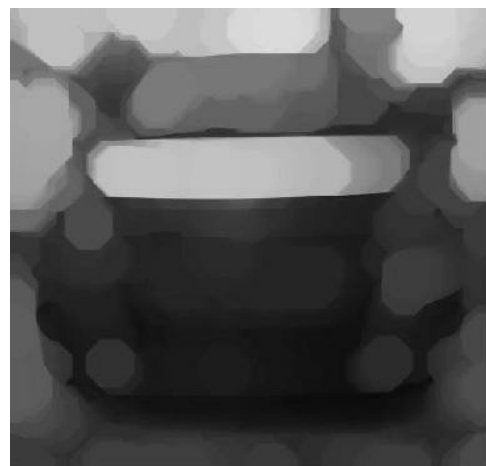
e = im2bw (d, Thres).

Fig. 6 (a) Gray scale image

Fig. 6 (b) Morphological operation

Fig. 6 (c) Image Subtraction

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Fig. 6 (d) Binary image

IV. LICENSE PLATE LOCATION IDENTIFICATION

The objective of License plate location identification is detecting the license plate of a vehicle image. The flow of operation is shown in Fig. 7.
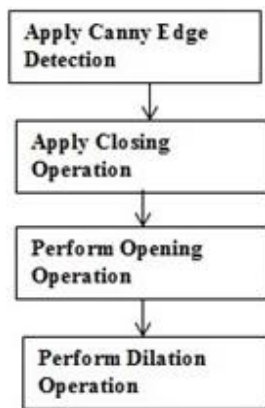

Fig. 7 License plate location identification Process

A. Canny Edge Detection

The Canny edge detection [9] is an edge detection method that uses a multi-stage algorithm to detect a wide range of edges in images. The main advantages of canny edge detection are good detection, good localization, and minimal response. Canny operator is the optimum-approaching operator of the product of SNR and the location. Canny algorithm smooth image by Gaussian filter, calculate the magnitude and direction of gray level gradient, has the non-maxima suppression on gradient magnitude, and detect and connect the edge from the candidate points by the high and low thresholds

1. Smoothing: To remove noise from the image we Smooth or blur the image using Gaussian filter.
2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes. They are in (4), (5)

$$G = \sqrt{G_x^2 + G_y^2} \tag{4}$$

$$\Theta = a\tan 2(G_y, G_x) \tag{5}$$

3. Non-maximum suppression: It is edge thinning technique. Only local maxima should be marked as edges and suppress all non-maxima.
4. Double threshold: Potential edges are determined by choosing two threshold points. Edge pixels value higher than the high threshold are marked as strong and edge pixels lesser than the low threshold are suppressed and edge pixels between the two thresholds are marked as weak.
5. Edge tracking by hysteresis: Final edges are determined by keeping all strong edges and suppressing all edges that are not connected to a very strong edge. Edge tracking can be implemented by Binary Large Object analysis using 8-connected neighborhood. In Fig. 8 (a) the output of canny edge detection is shown.

B. Morphological Operation:

1) Closing

It is defined as dilation followed by erosion *using the same structuring element for both operations [4]*. Closing is the dual of opening, *i.e.* closing the foreground pixels with a particular structuring element [15], is equivalent to closing the background with the same element. The effect of the operator is to preserve *background* regions that have a similar shape to this structuring element, or that can completely contain the structuring element, while eliminating all other regions of background pixels. It can be derived from the fundamental operations of erosion and dilation. The exact operation is determined by a structuring element. Closing is performed to remove pepper noise. The output is shown as shown in Fig. 8 (b). The closing of an image *f* by a structuring element *s* (denoted by *f • s*) is a dilation followed by erosion as in (6)

$$f \bullet s = (f \oplus s)\Theta s \tag{6}$$

2) Opening

Opening is defined as erosion followed by a dilation *using the same structuring element for both operations*. The outcome of the operator is to preserve *foreground* regions that have a similar shape to this structuring element, or that can fully contain the structuring element, while eliminating all other regions of foreground pixels. Erosion can be used to eliminate small clumps of unwanted foreground pixels, *e.g.* `salt noise', Opening is the *dual* of closing, *i.e.* opening the foreground pixels with a particular structuring element is equivalent to closing the background pixels with the same element.

The opening of an image *f* by a structuring element *s* (denoted by *f ∘ s*) is erosion followed by dilation as in (7)

$$f \circ s = (f\Theta s) \oplus s \tag{7}$$

3) Dilation

The basic effect of this operator on a binary image is to

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gradually enlarge the borders of regions of foreground pixels. Thus, areas of foreground pixels increase in size while holes within those regions become smaller. Dilation is the *dual* of erosion i.e. dilating foreground pixels is equivalent to eroding the background pixels. It can be used to fill in small false holes in images so that noises like peppers noises are removed. Dilation can also be used for edge detection by taking the dilation of an image and then subtracting away the original image. The dilation of an image *f* and a structuring element *s* is represented by $f \oplus s$ and it produces a new binary image $g = f \oplus s$ with ones in all locations (x,y) of a structuring element's origin at which that structuring element *s* hits the input image *f*, i.e. $g(x,y) = 1$ if *s* hits *f* and 0 otherwise, repeating for all pixel coordinates (x,y). The final output of license plate detection is presented in Fig. 8 (c).
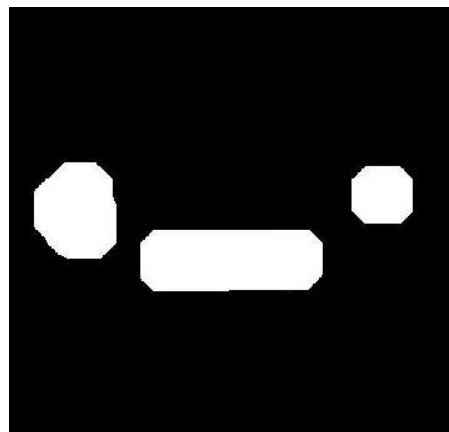

Fig. 8 (c) Dilation output

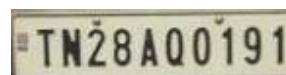Fig. 9 License plate Location Identification

Fig. 10 Refine output

Form the resultant image, measure the properties using the concept of connected component approach and identify the region which has rectangle properties. Then crop that particular region from the original image using *imcrop*. The final output of License Plate Location Identification is shown in Fig. 9. Repeat the same pre-processing and licenses plate extract once again and further refine the plate region exactly and the resultant output is shown in Fig. 10.

V. INDIVIDUAL CHARACTER SEGMENTATION

The isolated license plate is then separated individually to extract the characters for recognition. Segmentation is performed by labeling the connected pixels in the binary license plate image. The labeled pixels are analyzed and those which have the same size and aspect ratio of the characters are considered as license plate characters. This process includes the following sub process:

Step1. The extracted licenses plate image is as input and the image is converted to gray image for easy processing.

Step2. The gray image is converted to binary image with a help of a threshold value.

Step3. The binary image is Complemented i.e. it converts black to white and white to black.

Step4. Remove or filter image noise using medfilt2.

Step5. After removing the noise, each character is segmented using connected components technique.

Step6. Resize the extracted character to a standard size of 42 x 24 pixels.

The segmented output is shown in Fig. 11

Fig. 8 (a) Canny edge detection

Fig. 8 (b) Closing operation

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Fig. 11 Segmented Output

VI. LICENSE PLATE CHARACTER RECOGNITION USING TEMPLATE MATCHING APPROACH

Character is recognized using either classical or soft computation method. Classical recognition methods are 1. Template matching 2. Statistical technique 3. Structural techniques. Whereas soft computing recognition methods are 1. Neural networks (NNs) 2. Fuzzy logic technique 3. Evolutionary computing techniques [2], [3]. Template matching is a simple and straightforward method. The similarity between a character and the templates is measured. The template that is the most similar to the character is recognized as the target. Template matching is performed only after resizing the extracted character to the standard size of database. Many similarity measuring procedures are available some of them are Euclidean distance, Mahalanobis distance, Bayes decision technique, and the Hamming distance. Character recognition based on normalized cross correlation is the finest method to match the extracted characters with the templates. Each template scans the character column by column to calculate the normalized cross correlation. The template with the high value is the most similar one. Template matching is useful for recognizing single-font, not rotated, unbroken, and fixed-size characters [3], [11]. Since in license plate recognition the formats of the characters are fixed we use cross correlation template matching technique to identify the characters in license plate.

Template matching involves finding similarities between a predefined template and input image and produces an output that has highest similarity measure [5]. This process involves the use of a database of characters or numbers as templates. For recognition to occur, the current input characters compared to each template to find either an exact match, or the template with the closest representation of the input character. If I(i, j) is the input character, Tn (i, j) is the template, then the matching function s (I, Tn) will return a value indicating how well template and matches the input character [13].

Common matching functions are based on the following formulas as in (8) and (9):

$$s(I, Tn) = \sum_{i=0}^{w} \sum_{j=0}^{h} I(i, j) Tn(i, j) \tag{8}$$

$$s(I, Tn) = \frac{\sum_{i=0}^{w} \sum_{j=0}^{h} (I(i, j) - |I|)(Tn(i, j) - |Tn|)}{\sqrt{\sum_{i=0}^{w} \sum_{j=0}^{h} (I(i, j) - |I|)^2 (Tn(i, j) - |Tn|)^2}} \tag{9}$$

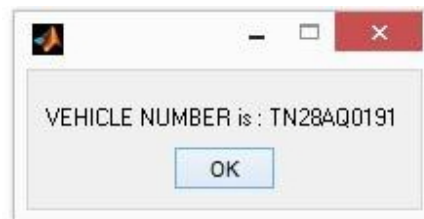The registration plate is recognized as show in Fig. 12

Fig. 12 Recognized license plate output

VII. EXPERIMENTAL RESULT

The tests were made on 500 images taken with the help of a digital camera, 96% of the number plates location were exactly identified and 4% images resulted locate the number plates along with unwanted non candidate regions. The correctly localized 98% plate images when passed through Character Recognition module provided 98% accurate results.

VIII. CONCLUSION

Proposed approach is successful than the existing method for Indian vehicles and the success rate is very much improved. The vehicle image is captured and processed to get information about the number plate for further applications. The future scope of this paper is license plate number validation which means verifying whether the registration number format is as per government standards.

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