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RESEARCH ARTICLE

Automatic Licenses Plate Recognition

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Abstract— This paper describes the Smart Vehicle Screening System, which can be installed into a tollbooth for automated recognition of vehicle license plate information using a photograph of a vehicle. An automated system could then be implemented to control the payment of fees, parking areas, highways, bridges or tunnels, etc. This paper contains new algorithm for recognition number plate using Morphological operation, Thresholding operation, Edge detection, Bounding box analysis for number plate extraction, character separation using Segmentation and character recognition using Template method and Feature extraction.

Key Terms: - morphological operation; number plate extraction; character segmentation; character recognition; feature extraction

I. INTRODUCTION

Automatic License Plate Recognition (ALPR) system is an important technique, used in Intelligent Transportation System. ALPR is an advanced machine vision technology used to identify vehicles by their number plates without direct human intervention. It is an important area of research due to its many applications. The development of Intelligent Transportation System (ITS) provides the data of vehicle numbers which can be used in follow up, analyses and monitoring. ALPR is important in the area of traffic problems, highway toll collection, borders and custom security, premises where high security is needed, like Parliament, Legislative Assembly, and so on.

Automatic License Plate Recognition (ALPR) is a form of automatic vehicle identification. It is an image processing technology used to identify vehicles by only their license plates. Real time LPR plays a major role in automatic monitoring of traffic rules and maintaining law enforcement on public roads. Since every vehicle carries a unique license plate, no external cards, tags or transmitters need to be recognizable, only license plate.

1.1 Motivation:-

The complexity of smart license number plate recognition work varies throughout the world. For the standard number plate, ALPR system is easier to read and recognize. In India this task becomes much difficult due to variation in plate model and their size. Character recognition part is also very difficult in Indian number plate. So flexible algorithm required for solved this task.

Nowadays vehicles play vital role in transportation. Also the use of vehicles has been increasing because of population growth and human needs in recent years. Therefore, control of vehicles is becoming a big problem and much more difficult to solve. License Plate Recognition systems are used for the purpose of effective control.

1.2 Overview:-

The ALPR work is generally framed into the steps: Number plate extraction, character segmentation and character recognition. Flowchart of ALPR system shown in Fig 1.1.From the entire input image, only the number plate is detected and processed further in the next step of character segmentation. In character segmentation phase each and every character is isolated and segmented. Based on the selection of prominent features of characters, each character is recognized, in the character recognition phase. Extraction of number plate is difficult task, essentially due to: Number plates generally occupy a small portion of whole image; difference in number plate formats, and influence of environmental factors. This step affects the accuracy of character segmentation and recognition work. Different techniques are developed for number plate extraction.

ALPR system consists of three modules; 1) Extraction of number plate, 2) Character segmentation, and 3) Character recognition. In this paper ALPR wok for Indian car is presented. Images are taken out with different illumination conditions, different background and orientation. Histogram equalization, median filter are used which take care of lighting and contrast problem. Sobel vertical edge detection and morphology is employed to locate the number plate. Projection analysis is used to segment the characters present on the plate. For recognition work template is used.

The rest of the paper is organized as follows: Section 2 explains the proposed algorithm for number plate extraction; Section 3 explains the algorithm used for character segmentation; Section 4 describes the number plate recognition algorithm using template of character and feature extraction. Experimental results are demonstrated in Section 5. Section 6 concludes the paper.

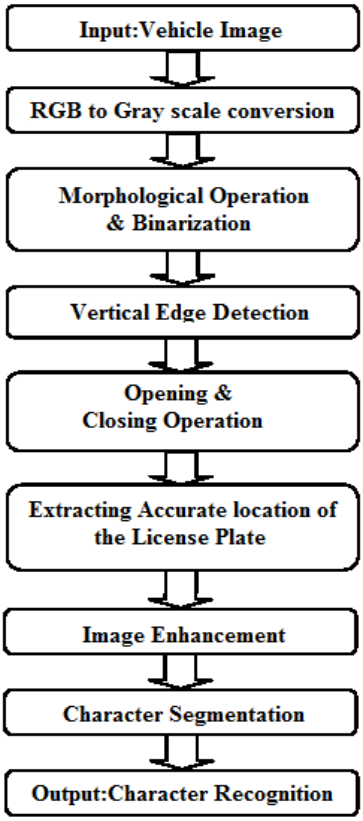


Figure 1.1: Flowchart of LPR Algorithm

II. LITERATURE SURVEY

Hao Chen et al [11] proposed the method in two steps. First, several candidates based on texture information similar to number plate are extracted. In the second step, auto-correlation based binary image and projection algorithm are used to verify the true candidate plate. Gisu Heo [12] developed number plate detection algorithm using group of lines forming rectangle at the plate boundary. Followed by this step is the vertical edge density algorithm to find out the plate area. Ozbay et al [13] devised smearing algorithm to locate the number plate. In

Korean license plate extraction, Mei Yu et al [14] proposed vertical edge detection followed by size, shape filter for edge area and edge matching technique based on plate model.

Every character on detected number plates is segmented in character segmentation step. Segmentation techniques based on projection analysis, Hough transform, region growing are proposed in the literature. Xinagjian He et al [17] used horizontal and vertical projection analysis for character segmentation.

Yuangang Zhang et al [18] implemented character segmentation using Hough Transform. In this, horizontal edges of the plate area were decided initially, using Hough Transform, which helped to segment the characters with the large rotation. Characters were segmented using vertical projection analysis based on the prior knowledge of the plate model. Feng Yang et al [19] developed region growing algorithm for character segmentation. Shen Zheng Wang et al [20] used connected component analysis for character segmentation.

Fundamental issue in character recognition is shape analysis. For the recognition of segmented characters, algorithms use Pattern/ Template matching, Computational Intelligence, statistical classifiers.

III. NUMBER PLATE EXTRACTION

Number plate extraction is the key step in ALPR system, which influences the accuracy of the system significantly. Extraction of number plate is difficult task, essentially due to: Number plates generally occupy a small portion of whole image; difference in number plate formats, and influence of environmental factors. This step affects the accuracy of character segmentation and recognition work. Different techniques are developed for number plate extraction. The goal of this phase, given an input image, is to produce a number of candidate regions, with high probability of containing number plate and validate for true number plate.

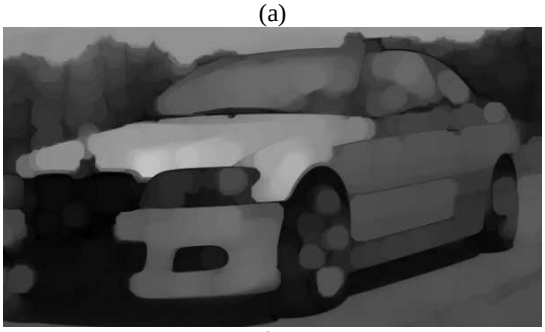
3.1 Image Acquisition and Pre-processing

In this system a high resolution digital camera is used to acquire an image. Images are taken in different background, illumination conditions, and at various distances from the camera to vehicle. Image converted RGB to gray scale all the processing steps are executed on gray scale image. Figure 3.1 (a) shows gray scale image. Pre-processing is mainly used to enhance the processing speed, improve the contrast of the image, and to reduce the noise in the image. In order to reduce the problem of low quality and low contrast in car images.

3.2 Morphological Operation

Morphological opening operation used using structure element on vehicle gray scale image then subtracted from original image .This operation remove pixel having a less than disk radius by opening it with the disk-shaped structuring element. Thus number plate and other parts which have less disk radius like lights are stay in new image and unwanted parts remove from image. Figure 3.1 (b) shows applying opening operation using disk structuring element on gray scale image. Figure 3.1(c) show subtraction between two images.

(a)



(b)

(c)

Figure 3.1: (a) Gray scale image, (b) Effect of Opening operation using disk, (c) image (a) – image (b).

3.3 Thresholding Operation

Threshold operation is converted gray scale image into binary image by calculating level of threshold. First find minimum and maximum value of pixel from image. This operation converted all pixels in 0-1 form and makes further processing simple. Figure 3.2 shows effect of thresholding operation.

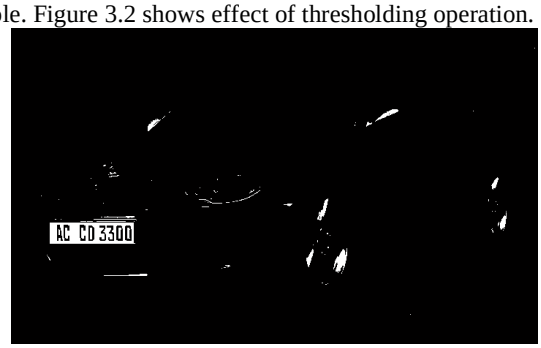


Figure 3.2: Thresholding image.

3.4 Vertical Edge detection

The characters on number plate region contain abundant edges as compared to background area. This feature is employed for locating the candidate plate area from the input image. Sobel vertical edge detection is used to find out the regions which have high pixel variance value [6]. To extract candidate number plate area from the entire image, threshold is used to select rows which are having particular white pixel density. Fig. 3.3 shows the result of effect of using, Sobel vertical edge detection.

Figure 3.3: Sobel vertical edge detection

3.5 Candidate Plate Area Detection

Morphological operations aim to remove unrelated objects in the image. Closing and opening are used to extract candidate plate areas from the entire image. Sometimes background areas may also get declared as candidate plate. Hence to remove the fake candidates, plate validation is done using the aspect ratio of the plate and horizontal cuts [7] in the number plate. Figure 3.4 show number plate area detection in whole image.

Figure 3.4: Plate area detection image

3.6 True Number Plate Extraction

After the detection of candidate number plate area, Bounding Box analysis is used to extract plate area from the original image. From the Bounding Box analysis, respective row and column indices of plate area are found out. Once the indices of number plate are known, the number plate is extracted from original gray scale image. The result is as shown in Fig. 3.5

Figure 3.5: Extracted true number plate.

3.7 Adjust Number Plate appropriate angle

This operation is used when number plate is not in horizontal position. Rotation of number plate is required for true recognition. Fig 3.6 shown rotated plate operation. This operation perform scanning number plate image from left side and right side then find two point (x1,y1) and (x2,y2) from top white part. Calculate slop and rotation angle from below equation.

$$M = \frac{(y2 - y1)}{(x2 - x1)}$$

$$\theta = \tan^{-1}(M)$$

Where, M is slop and Theta is rotation angle.

(a) (b)

Figure 3.6: (a) Extracted plate, (b) Rotated plate

IV. CHARACTER SEGMENTATION

Character isolation from the number plate region is the important step in ALPR system, which influences the accuracy of character recognition significantly. The goal of this phase, given the number plate image, is to segment all the characters, without losing features of the characters. This phase consists of the sequence of operations as, character region enhancement, connected component analysis and projection analysis.

4.1 Character Region Enhancement

For character Region Enhancement first converted true number plate image into binary image by using gray thresh (image) function. Erosion operation is used for focusing each character. Here characters are in black

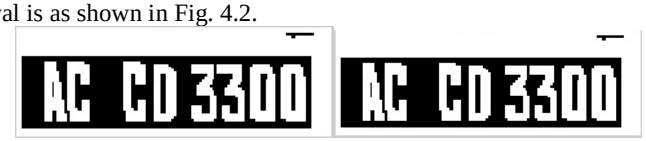
colour so erosion made characters thick. Figure 4.1(a) show Binarized image and figure 4.1(b) show erode image.

(a) (b)

Figure 4.1: (a) Binarized number plate, (b) Erode image

4.2 Connected Component Analysis

To remove the noise, other than characters on the plate, connected component analysis is used. Each labelled matrix of 8-connectivity pixels is evaluated based on the area threshold. The result of connected component analysis and noise removal is as shown in Fig. 4.2.



(a) (b)

Figure 4.2: (a) Converted Black to white, (b) Connected component analysis

4.3 Vertical Projection Analysis

Character segmentation is implemented to isolate each character on the number plate. Vertical projection analysis is used to find the gaps between the characters. The characters are segmented based on the number of valleys in projection. Row and column indices of each character are recorded, and it is extracted from the original gray scale number plate. This proposed work isolates every letter and digit on the number plate oriented horizontally in one row, along the width of number plate. Figure 4.3 show segmented character.

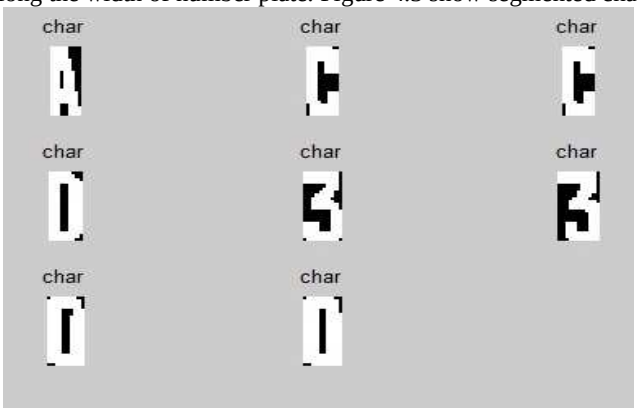


Figure 4.3: Segmented character image

V. CHARACTER RECOGNITION

The character recognition phase consists of two Method: 1) Template Matching, 2) Feature Extraction.

5.1 Template Matching [8]

The character recognition phase consists of two steps: 1) Loading template and Character normalization, 2) Matching character with template character.

5.1.1 Template loading

This operation loads a template of character. Take 24 X 42 pixel A to Z alphabet and 0 to 9 number images. Read this all image and store in database. It becomes 36 character templates. This template made global.

5.1.2 Character Normalization

Segmented characters have very much variation in size. In this phase, all the characters are normalized to predefined height (Vertical Length) in pixel. As the characters always have variable width (Horizontal Length), each character image is normalized to a size of 24 X 42, by image mapping technique.

5.1.3 Template matching

Normalized character image compare with each template character image and find correlation between segmented character and template character. Selecting the most relevant image and write into text file. Figure 5.2 shows text file which is contain output of number plate.

5.2 Feature based character Recognition

Feature Extraction serves two purposes; one is to extract properties that can identify a character uniquely. Second is to extract properties that can differentiate between similar characters. A character can be written in a variety of ways, and yet can be easily recognized correctly by a Human. Thus, there exist a set of principles or logics that surpass all variation differences. Thus, the features used by the system work upon such properties which are close to the psychology of the characters.

5.2.1 Zoning Feature Extraction [9]

In the zoning feature extraction, a character is usually divided into zones of predefined size. These predefined or grid sizes are typically of the order 2x2, 3x3 etc. Some typical zoning of a character is shown in Fig.5.1.

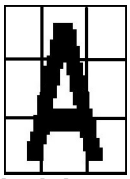


Fig.5.1 A character divided into 3x3 zones using grid.

By considering the bottom left corner of each image as the absolute origin (0, 0), the phase angle of each grid at {x, y} is computed as below

$$\theta = \tan^{-1}\frac{y}{x}$$

Where {x, y} is top right corner point of each grid. So theta is difference for each zone.

While computing any feature value, each pixel contribution utilizes this value to make it a unique contribution. For instance, the box feature of a grid is computed as follows. By considering the bottom left corner as the absolute origin (0, 0), the coordinate distance (Vector Distance) for the kth pixel in the bth box at location (i, j) is computed as:

$$d_k^b = \left(i^2 + j^2\right)^{\frac{1}{2}}$$

By dividing the sum of distances of all black pixels present in a box with their total number, a modified box feature is obtained ( ) for each box as follows

$$\lambda = \frac{1}{N}\sum_{k=1}^{n_n} d_k^b$$

Where N is total number of pixels in a box. nb is the number of black (pattern) pixels in bth box.

The feature of each zone is computed as follows

$$\lambda_{\text{mod}} = \lambda\cos\theta$$

Where α is a multiplying factor taken as 1 in our experiments. As the range of cos is 0 to1 only, α was introduced.

5.2.2 Regional Feature extraction

The following regional feature are extracted from character image

1) 'EulerNumber' — Scalar that specifies the number of objects in the region minus the number of holes in those objects. This property is supported only for 2-D input label matrices. regionprops uses 8-connectivity to compute the EulerNumber measurement.

2) 'Eccentricity' — Scalar that specifies the eccentricity of the ellipse that has the same second-moments as the region. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value is between 0 and 1. (0 and 1 are degenerate cases; an ellipse whose eccentricity is 0 is actually a circle, while an ellipse whose eccentricity is 1 is a line segment.) This property is supported only for 2-D input label matrices.

3) 'Extent' — Scalar that specifies the ratio of pixels in the region to pixels in the total bounding box. Computed as the Area divided by the area of the bounding box. This property is supported only for 2-D input label matrices.

4) 'Orientation' — Scalar; the angle (in degrees ranging from -90 to 90 degrees) between the x-axis and the major axis of the ellipse that has the same second-moments as the region. This property is supported only for 2-D input label matrices.

5) 'ConvexArea' — Scalar that specifies the number of pixels in 'ConvexImage'. This property is supported only for 2-D input label matrices.

6) 'FilledArea' — Scalar specifying the number of on pixels in FilledImage.

7) MajorAxisLength' — Scalar specifying the length (in pixels) of the major axis of the ellipse that has the same normalized second central moments as the region. This property is supported only for 2-D input label matrices.

8) 'MinorAxisLength' — Scalar; the length (in pixels) of the minor axis of the ellipse that has the same normalized second central moments as the region. This property is supported only for 2-D input label matrices.

5.2.3 ANN Training and Classification [10]

The character sequence of license plate uniquely identifies the vehicle. It is proposed to use artificial neural networks for recognizing of license plate characters, taking into account their properties to be as an associative memory. Using neural network has advantage from existing correlation and statistics template techniques that allow being stable to noises and some position modifications of characters on license plate. Before the character recognition can take place, the ANN is 'trained', so that it can develop the capability of mapping various inputs to the required outputs and effectively classify various characters. For training the ANN, we use the 'Vectors' generated by the 'Database Templates' using the above mentioned Feature Extraction techniques. The above mentioned Zoning feature and 8 different types of features have been used to generate 17 parameters, which are fed to the ANN. We are use 10 types of each character so total input image is 360. Thus, a matrix of 17x360 values is fed to the ANN to receive 36 different values at the output, one for each character in the database. It may be noted that the ANN uses Back propagation algorithm for Learning. The 'Target' values are specified by the system programmer to accommodate for small recognition errors, which may be changed from application to application.

The ANN was trained for 1000 iterations, which took around 21 seconds to complete. The Training Function was set to use 'Sum Squared Error' rather than 'Mean Squared Error', because the system needed to calculate the effect of joint errors in all the parameters, rather than overall error. Learning rate is 0.01 and An error goal of 1e-1 was achieved by the ANN.

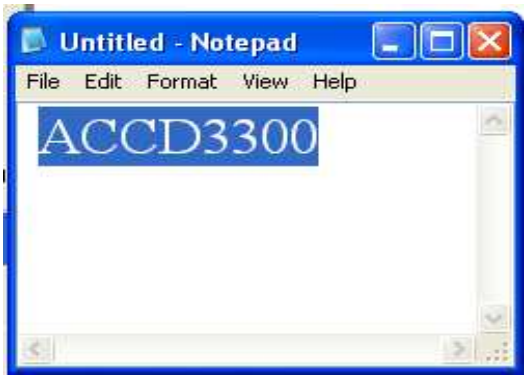


Figure 5.2: Output Text file by both method

VI. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

A database consists of different sized JPEG colored images. Total 150 images are used to test the algorithm. The images are taken with different background as well as illumination conditions. Experiments show that the algorithm has good performance on number plate extraction, and character segmentation work. It can deal the images correctly, with noise, illumination variance, and rotation to ±50. This work is implemented using MATLAB. Table 6.1 illustrates number plate extraction and character segmentation success rate.

Table 6.1: number plate extraction and character segmentation success rate

Algorithms	Total no. of success image	Success rate (%)
Number plate Extraction	135	90
Character segmentation	127	85
Character Recognition using Template based	120	80
Character Recognition using feature based	124	84

Deep shadows and reflections have an impact on number plate extraction work. Because of uneven illumination, stained number plates, true number plates could not get correctly extracted. Failure in character segmentation was mainly because of merging of characters on number plate, stained number plates, orientation of the image and poor illumination.

Character recognition work is done on 10 digits (0 to 9) and 26 alphabets (A to Z). The recognition rate achieved is 80% using Template matching but 84% using feature Extraction. This analysis show that feature extraction method using neural network give good performance then direct template matching. In feature extraction method training is done by neural network so efficiency of result increases. In template matching false recognition is due to similarity in the character shape, e.g. 6 and B, 5 and S etc, but when we extract feature from character image the false recognition is removed because different type of same character is trained and it is recognized correctly.

VII. CONCLUSIONS AND FUTURE WORKS

Conclusions

An algorithm for vehicle number plate extraction, character segmentation and recognition is presented. Database of the image consists of images with different size, background, illumination, camera angle, distance etc. The experimental results show that, number plates are extracted faithfully based on vertical edge detection and connected component algorithm, with the success rate of 90%. Character segmentation phase using connected component analysis and vertical projection analysis works well with the success rate of 85%. Feature based character recognition based on neural network give better result than template method. The success rate achieved for character recognition is 84%.

Future works

In future we have to find maximum feature of character and improved our result in character recognition. There are still some further researches to do. For example, it can't work with some other kind of license plate, such as two-row plate. This problem will be solved in the further work.

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