Smart License Plate Recognition System based on Image Processing

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Abstract—This report describes the Smart License Plate Reorganization System, which can be installed into a tollbooth for automated acceptation of vehicle license plate details using an image of a vehicle. This Smart License Plate Reorganization system could then be implemented to control the payment of fees, highways, bridges, parking areas or tunnels, etc. This report contains new algorithm for acceptation number plate using Structural operation, Thresholding operation, Edge detection, Bounding box analysis for number plate extraction, character separation using separation and character acceptation using Template method and Feature extraction.

I. INTRODUCTION

Smart License Plate recognition (SLPR) system is an important technique which can be used in Intelligent Transportation System (ITS). SLPR is an advanced machine vision technology used to identify vehicles by their number plates in which there is no need any human intervention. It is a very 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 analyses and monitoring. SLPR is important in the area of highway toll collection, traffic problems, borders and custom security, premises where high security is needed, like Legislative Assembly, Parliament, and so on.
Smart License Plate recognition (SLPR) is a form of automatic vehicle identification. It is an image processing technology used to identify vehicles with the help of only their license plates. SLPR plays a major role in automatic monitoring of traffic rules and maintaining law coercion on public roads. Since every vehicle carries a predicate license plate, no any external cards, tags or transmitters need to be perceptible, only license plate perceptible.

The complexity of smart license number plate acceptation work varies throughout the world. For the standard number plate, SLPR system is easier to read and recognize.

In our country India this task much more difficult because of variation in plate model and their size. Character acceptation part is also very difficult in Indian number plate. So flexible algorithm required for solved this task.

SLPR system consists of following modules: 1) Extraction of number plate, 2) Character separation, and 3) Character acceptation. In this report, SLPR work for our Indian car. Images are carrying out with different illumination conditions, different background and orientation. To take care of lighting and contrast properly Histogram equalization and median filter are used. Sobel vertical edge notation and structurally is employed to locate the number plate. To separate out the characters

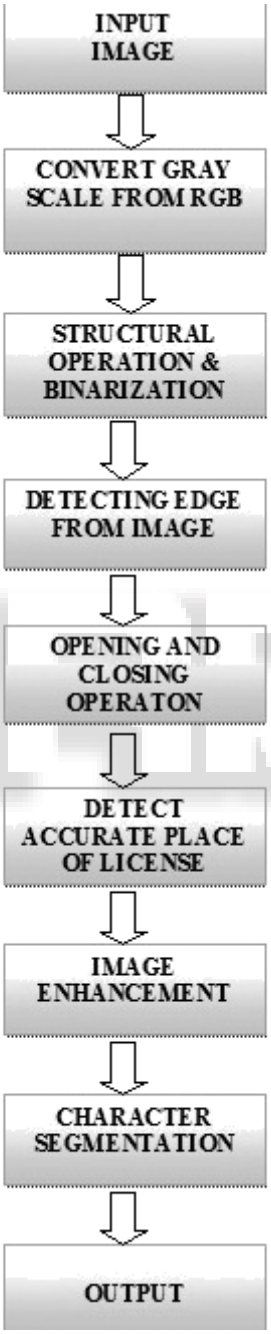

Fig. 1: Flowchart of SLPR Algorithm

Present on the number plate Projection analysis is used. For acceptation work template is used. .The rest of the report is organized as follows: Section 2 shows the Literature survey; Section 3 explains the projected algorithm for the use of number plate extraction; Section 4 explains the algorithm used for character separation; Section 5 describes the number plate acceptation algorithm using template of

character. Section 6 shows the Experimental results and Section 7 conclusion.

II. NUMBER PLATE EXTRACTION

Number plate extraction is the very important step in SLPR system which affects the accuracy of the system significantly. Basically extraction of number plate is difficult task due to many problems like Number plates generally occupy only a small portion from the whole image; there are many difference in number plate formats, and bear upon of environmental factors. This step affects the accuracy of character separation and acceptation work. There are Different types of techniques are developed for number plate extraction. The final goal of this phase, we have to give only an input image with the use of this input image detect only the region which contain the number plate of vehicle and it is validate for true number plate.

A. Image Acquisition and Pre-processing

In this system we are using high resolution camera to get an image. Here images are taken in different illumination conditions, background and at various distances from the camera to vehicle. Image converted into gray scale from RGB. Now all next steps are penalize on gray scale image. Figure 2(a) shows gray scale image. With the use of pre-processing we can raise the processing speed, improve the contrast of the image and we can also reduce the noise in the image.

B. Structural Operation

Structural opening operation used using structure element on vehicle gray scale image then subtracted from original image. Into this operation remove pixel which has less radius than disk radius with the help of disk-shaped structuring element. So the number plate and light which has less disk radius are remaining in next phase and the other part which is not necessary remove from the image.

C. Thresholding Operation

With the use of Threshold operation we get binary image from gray scale by calculating level of threshold. First we have to find the minimum and maximum value of pixel from image. While we are performing this operation all pixel is converted in 0-1 form so the next processing simple

D. Vertical Edge notation

The characters which are on number plate area contain abundant edges as compared to background area. This feature is utilized for locating the candidate plate area from the input image.

Fig. 2: Gray scale image

Fig. 3: Effect of Threshold

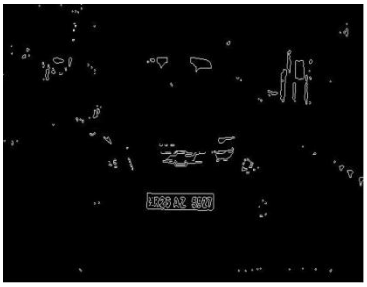

Fig. 4: Sobel vertical edge detection

Sobel vertical edge notation is used to find out the regions which have high pixel variance value [8]. Thresholding operation is used to select rows which have particular white pixel density. With the use of this operation we can extract candidate number plate region from the whole image. From the Fig. 2(c) we can see the result of Sobel vertical edge notation algorithm.

E. Candidate Plate Area Notation

The aim of structural operation is that remove unnecessary objects which is not require in the image. To separate candidate plate areas from the whole image opening and closing operation are used. In some cases background areas of the image also acquire as a candidate plate. So to remove the forge candidates, plate validation is require and it is done using aspect ratio of the number plate horizontal cuts [11] in the number plate.

F. True Number Plate Extraction

When the notation of candidate number plate area is done Bounding Box analysis is Require. Which is used to separate out plate area from the whole 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 takeout from original gray scale image. The result is as shown in Fig. 5

Fig. 5: Extracted true number plate.

2.7 Adjust Number Plate in appropriate angle

The operation adjust number plate is used when number plate is not in proper way. So this operation performs rotating operation for true acceptation. Fig 5 shows the result of this operation. This operation perform sacrificial neural networking in which find two points from the left side and right side of the number plate and calculate the slop equation.

The equation is shown below.

$M = (y2-y1) / (x2-x1)$

Theta = tan-1(M).
Where, M is slop and Theta is rotation angle.

Fig. 6: Extracted plate, Rotated plate

III. CHARACTER SEGMENTATION

The important step of SLPR system is character isolation from the number plate area, which touch the accuracy of character acceptation significantly. Given the number plate image, is to separate all the characters, without losing any feature of character from the number plate is the final goal of this phase. In to this phase there is a sequence of operation like character region enhancement, connected component analysis is and projection analysis.

A. Character Region Enhancement

Fig. 7: Binarized number plate

Into this phase the image of number plate is converted into binary image which is done with the use of graythresh function. Here Gnaw operation is used for focusing each and every character from the number plate. Gnaw operation made every character thick because all character in black colour. Fig 5 and Fig 8 show the result of Binaries image and Gnaw image simultaneously.

B. Connected Component Analysis

Then necessary noise from the number plate is removed into the connected component analysis. As per the based on the area of threshold every matrix of 8 pixels is evaluated. Into the fig 8 we can see the result of connected component analysis and noise removal.

Fig. 8: Gnaw image, Converted Black to white, connected component analysis

C. Vertical Projection Analysis

Now the final operation in SLPR is to separate out each character from the number plate and take into one text file. This operation is performing into character separation phase. Now to find out the gaps between two character vertical projections analysis is used. As per the based on the number of projection all character are separated. Each character's Row and column indices are recorded and it is takeout from the original gray scale number plate. This complete operation is performing to isolate every character from the number plate which is horizontally in one row. The result of this operation is shown in fig 4

IV. CHARACTER RECOGNITION

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

A. Template Comparing [25]

The character acceptation phase consists of following steps: 1) Lading template 2) Character normalization, 3) Comparing character with the Template comparing

1) Lading Template

In to this operation loads a template of character. We are taking 24 X 42 pixel A to Z alphabet and 0 to 9 number images. Here read all image and it is store in our database. So there are total 36 characters in database. This template work as global.

B. Character Normalization

Now when we separate out the character at that time there is too much variation in size of character. So into this phase all character is normalizing into predefined size in pixel.

Each character is normalized into a size of 24 X 42 with the use of image mapping technique.

1) Template comparing

Now this task is perform with the database in which normalized character is compare with each template character image and finds the matching between separated character and template character. After performing this task selecting the most relevant image and it is written into text file. Fig 6 shows text file which is contain output of number plate.

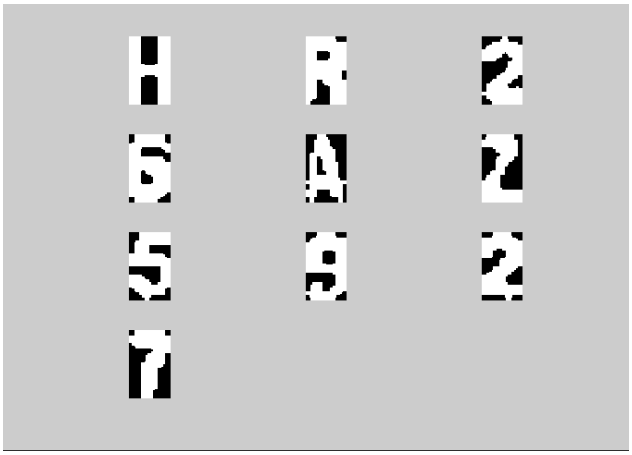

Fig. 9: Character 24x42 size image

C. Feature based character Acceptation

Now this phase is little bit difficult. Into this phase there are two purposes. 1) To extract property which is used to identify a character uniquely 2) To extract properties this can differentiate between similar characters. Now the problem is that character can be written in a different way and yet it can be easily recognized by a Human. Thus, there exist a set of principles or logics that stand out all differences. Now the futures work is that the system has

properties which are close to the psychology of the characters.

1) Regularizing Feature Extraction [27]

Now into this phase every character is usually divided into zones of predefined size. Into this predefined grid sizes are in the order of 3x3, 4x4 etc. Fig 5 shows the result of regularizing of a character. 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

$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

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 k^{th} pixel in the b^{th} box at location (i, j) is computed as:

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

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

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

Where N is total number of pixels in a box. n_b is the number of black (pattern) pixels in b^{th} box.

The feature of each zone is computed as follows

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

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

2) Regional Feature extraction

The following regional features are Takeout from character image

1) 'Euler Number' — 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. Region props use 8-connectivity to compute the Euler Number 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 separate.) 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) 'Convex Area' — Scalar that specifies the number of pixels in 'Convex Image'. This property is supported only for 2-D input label matrices.
6) 'Filled Area' — Scalar specifying the number of on pixels in Filled Image.
7) Major Axis Length' — 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) 'Minor Axis Length' — 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.

3) ARTIFICIAL NEURAL NETWORKS Training and Classification [26]

In SLPR sequence of character of license plate identifies the vehicle. Now here we are using artificial neural network for recognize of license plate characters. There is a one of the best advantages of Neural Network are existing correlate in and statistics template techniques which is use to stable to noises and some modification in the position of characters of number plate. The ARTIFICIAL NEURAL NETWORKS is 'trained' before the character acceptation can take place so it can improve the capability of mapping various inputs to the required outputs and it can effectively classify various characters. We use the 'Vectors' which is generated by the 'Database templates' with the use of Feature Extraction techniques for training the ARTIFICIAL NEURAL NETWORKS. As we have above discuss regularizing feature and many different types of feature, all are used to generate 17 parameters, which is use in ARTIFICIAL NEURAL NETWORKS (ANN). In Neural network we are using 10 types of every character so total number of images in our database are 360. So there are total 17x360 values in to the ANN to receive 36 deferent values at the output side. Here we have to note down that Back propagation algorithm is used in the ARTIFICIAL NEURAL NETWORK for Learning. System programmer specify the 'target' value so we can accommodate at the small acceptation errors, which may be change from one application to another application.

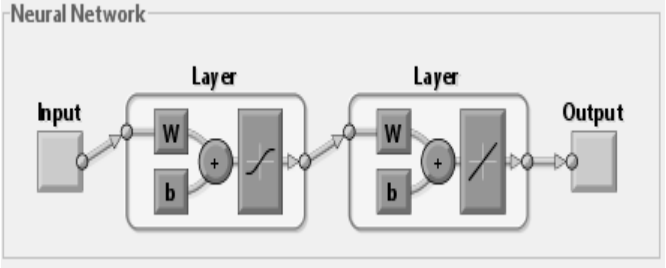

Fig. 10: Neural Network

The ARTIFICIAL NEURAL NETWORK is good for much

Condition and it is very reliable for much iteration and to complete the process it takes around 21 seconds. Here we are using 'Sum Squared Error 'for Training function in place of 'Mean Squared Error' because the system calculate the effect of joint errors for all the parameters in place of all over errors. The learning rate of ANN is 0.01. An error goal of 1e-1 was achieved by the ANN.

4) Analysis of different hidden neural

ARTIFICIAL NEURAL NETWORKS has three layer input, hidden and output shown in figure 8. Here problem is how to defined number of hidden neuron in our implementation, so we have taken different number of neuron and done analysis using Regional and regularizing feature. Table 1 shown analysis of number of neuron with correct character acceptation and time analysis using regional feature and regional + regularizing feature. Table shows that training time is increase with increased number of hidden neuron and number of correct character acceptation increase with increased number of hidden neuron. Here analysis shows that when we have used only regional feature then all character correctly recognized using 600 hidden neuron and when we have used regularizing feature with regional feature then all character correctly recognized using 300 hidden neuron which is half of previous. Time required for correct acceptation using only regional feature is 38.2 secs and time required for correct acceptation using regional + regularizing feature is 17.6 secs. This analysis shows that when we have taken more and more feature its decrease number of hidden neuron for correct acceptation and make algorithm faster because less hidden neuron take less training time.

V. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

A database consists of different sized JPEG coloured 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 separation 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 separation success rate.

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

Table. 1: number plate extraction and character separation success rate

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 Takeout. Failure in character separation was mainly because of merging of characters on number plate, stained number plates, orientation of the image and poor

Illumination.

Character acceptation work is done on 10 digits (0 to 9) and 26 alphabets (A to Z). The acceptation rate achieved is 80% using Template comparing but 84% using feature Extraction. This analysis show that feature extraction method using neural network give good performance then direct template comparing. In feature extraction method training is done by neural network so efficiency of result increases. In template comparing false acceptation 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.

VI. CONCLUSIONS & FUTURE WORKS

A. Conclusions

An algorithm for vehicle number plate extraction, character separation and acceptation 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 Takeout faithfully based on vertical edge notation and connected component algorithm, with the success rate of 90%. Character separation phase using connected component analysis and vertical projection analysis works well with the success rate of 85%. Feature based character acceptation based on neural network give better result than template method. The success rate achieved for character acceptation is 84%.

B. Future works

In future we have to find maximum feature of character and improved our result in character acceptation.

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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