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Automated License Plate Recognition

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Abstract

A vehicle can be identified with its license number. This number is generally used for many applications. So a method to find out the license number automatically is very much necessary. License plates were usually extracted from static images of vehicles by clustering and then the characters are segmented using dilation process. But this static image method does not give very accurate results when the license plates are of different sizes or different color. It could not succeed in recognition of license plates where the characters are broken and illumination changes. So, the proposed system is designed in such a way, to solve these problems. It takes a real time image as input. License plate can be detected from the input by detecting edges using Sobel edge detection technique, followed by morphological operations. The detected license plate can be extracted and the characters in the license plate are segmented by connected component analysis. This is a faster and more accurate approach. The segmented characters can then be matched with character templates stored in the database and the correct character is recognized. Images of vehicles, taken at real time at various angles having different backgrounds and illumination conditions license plates of any color or size and characters of any font style and language are recognized.

Keywords: Edge Detection, Image Processing, License Plate Recognition, Segmentation, Template Matching

1. Introduction

This paper proposes an efficient method to recognize license plates automatically from images. License plate is the identifier, which differentiates two vehicles of same model and color. So identification of which helps in many applications such as for toll fee payment, parking fee payment, locating stolen vehicles. For intelligent traffic monitoring, this system can help in tracking cars which cross the signal during red signal timing. The paper proposes an efficient approach to recognize license plates.

This project uses image processing techniques on the acquired image for extraction of the license plate after which it recognizes the characters present on it. But practically, license plates differ by color, size, inclination angle, location, font style, language. The environment of vehicle shots has different illumination conditions. So more efficient techniques along with higher accuracy is needed to overcome these problems.

The entire process begins with image acquisition, where the image is acquired and given as an input to the system. The license plate can be extracted from the plate, then the segmentation of the characters on the license plate can be recognized to give the license plate information as output.

The main focus of this paper will be regarding the explanation of techniques which work with the same accuracy to different types of license plates. Characters of different font styles and languages (English, Tamil) can also be recognized by this method. License plate recognition of vehicles with different lighting conditions is also achieved.

2. Related Work

Gee-Sern Hsu, et al.[1] had suggested using License Plate Recognition (LPR) especially for applications categorized as access control, traffic law and road patrol. The paper explains methods to recognize plates irrespective of plate size and illumination condition. Plates are located by using Sobel operator for clustering dense set of edges and of rectangular shape. Characters are segmented by a blob analysis technique named Maximally Stable Extreme Regions detector and characters are recognized by template matching technique.

In[4] the background is filtered for further operations leaving the foreground vehicle as non black and the background to be black. Rinku Solanki, et al.[7] had suggested to do horizontal segmentation by finding mean of the local minima. The right and left edges are also located, to form candidate regions. All such detected candidate regions are analyzed with two features-aspect ratio and edge density to result in only the license plate region. The detected plate is then subjected to dilation and smearing to separate closely spaced characters. Then the characters are cut by finding the starting and end points. Segmented characters are then recognized by matching with the template stored in memory, using correlation measure. The system achieves 95.74% efficiency. But this system works for images having only yellow colored plain background.

Divya Gilly, et al.[6] had proposed license plate recognition for vehicles with English number plates. This system also assumes of having only white colored license plates with black letters. Initially for pre-processing, Otsu algorithm is used to remove the shadows or dirt in the license plate region and convert the grey scale image to a binary image. Connected components analysis is used to label all the connected regions. The plate is then detected from all the labeled regions using aspect ratio and area of license plates. Characters are segmented by using the same connected component analysis. Character recognition is done using template matching technique. This system achieved 80% accuracy. But it expects the license plates to have an aspect ratio of 4 to 10.

In[7] the system works based on the assumption that license plates have same height and width proportion. The plate localization is done using edge and color information. The image is used initially for extracting edges and then using connected component analysis, the plate is located. In segmentation step, a simple method like adaptive binary thresholding is used along with some clustering. If results are negative, then some other methods are added progressively increasing its complexity. The Optical Character Recognition method used is an Artificial Neural Network[10]. Back propagation algorithm is used where the network's output and the desired output from that input are compared. The error at each weight is calculated and adjusted. Then the error values are propagated to higher levels. Thus this system achieves 80% accuracy.

3. Proposed System

The proposed system is designed to overcome most of the challenges faces by earlier approaches. The block diagram of Automated License plate Recognition is shown in Figure 1. This system has basically four steps:

Step 1: Acquiring the image from a continuous video stream.

Step 2: Extracting the license plate from the image by using Sobel edge detection technique, followed by morphological operations.

Step 3: Segmenting the characters in the extracted license plate by connected component analysis.

Step 4: Recognizing the segmented characters by template matching method using normalized cross correlation measure.

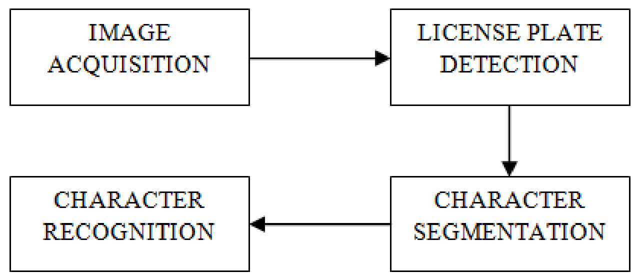

Figure 1. License plate recognition steps.

Algorithms used for each step are explained in the following sections.

3.1 Image Acquisition

This step usually involves retrieving images from a source that is automatically capturing images. This automatic capturing is achieved using hardware sensors such as magnetic loop detector, infrared sensor. Whenever a vehicle gets detected by the sensor, image is acquired and passed on as input to the next step[9].

This can also be done by using software triggering, especially in traffic monitoring for recognizing vehicles that cross the red signal. It works such that image is acquired whenever the surveillance camera detects a movement during that time.

3.2 License Plate Extraction

The aim of this step is to detect the license plate in the image and to extract it for further processing. The image acquired is first converted to gray scale image for facilitating easier processing.

3.2.1 Edge Detection

The gray scale image is used for detecting edges by Sobel edge detection approach. This approach uses two masking matrices. They are convolved with the gray scale image separately. The masking matrices are,

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Matrix G_x is convolved with the gray scale image for detecting horizontal edges. Matrix G_y is convolved with gray scale image separately to get the vertical edges. Then the gradient value for each pixel is calculated, by the squaring the convolved values and summing them. A threshold value is defined for detecting edges. The edge pixels have gradient value greater than threshold value, so they are assigned 1 and non-edge pixels will have lesser gradient value, so are assigned 0. So, the result obtained is an image with all the edges detected from the gray scaled version of original image.

3.2.2 Morphological Operations

The smaller edges which are detected other than that of license plates are removed from the edge detected image. Then the closed candidate regions, formed by the detected edges will include license plate.

This can be done by using aspect ratio. But for Indian vehicles, aspect ratio cannot be helpful, as they don't have a perfect aspect ratio. So, to acquire only that region, firstly the image is subjected to filling operation. The previously acquired intermediate result is subtracted from the filled image to get only the filled candidate regions. Thus only the closed regions, from the edge detected image are obtained[12].

To get the exact form of license plate as in the input image, the subtracted image has to be multiplied with original input. As the original input is RGB image, the multiplication is done for R, G, B channels separately. The closed regions will have pixel value 1 and other pixels will have value 0. The pixel with value 1, when multiplied gives the same R, G, B values as of original input. The pixel with value 0 will remain 0 after multiplication. The result will be extracted license plate with the same color as it is in the original input.

3.3 Character Segmentation

The purpose of this step is to segment the characters present in the extracted license plate and to get the individual characters after segmentation.

The extracted license plate is converted to binary image for easier identification of components. The image will have pixel value 1, in the background of license plate characters, within the closed region. The binary image is then complemented converting all 1's to 0's and vice versa. This will change the background of license plate region to pixels of value 0. The lighter pixels are pixels with value 1, in a complemented image. Those pixels, which are connected to the image border, must be cleared. This makes the image to have pixel value 1, in the license plate characters' pixels and value 0 in other pixels[11].

The acquired intermediate result is then subjected for connected components labeling. The working of this approach is shown in Figure 2. It scans the whole image and finds connected components.

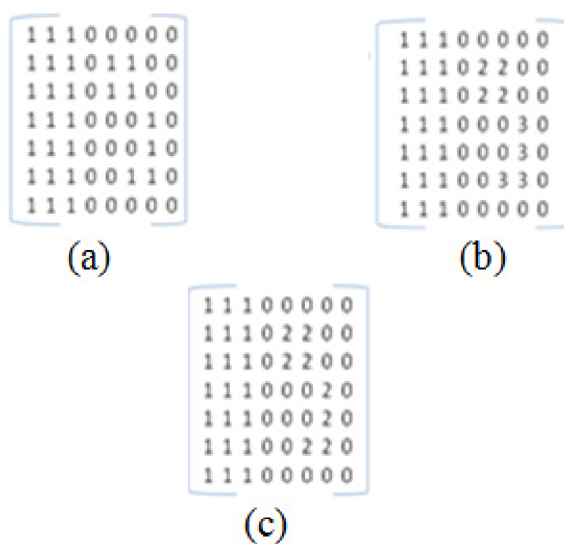

Figure 2. Connected component analysis **(a)** Sample input matrix **(b)** Using 4 neighbors **(c)** Using 8 neighbors.

In Figure 2, a sample input is shown in Figure 2(a). It is a binary matrix with pixel values as either 1 or 0. The input sample is scanned for a pixel with value 1, if found, it is labeled as 1 and their connected pixels are scanned followed by labeling them also as 1. The same step is done for all connected pixels found in the previous iteration. This continues until the connected pixels result in 0 for neighboring pixels found from previous iteration. After labeling all the connected pixels of that component, the pixel values which have already been labeled are changed to 0. The resulting image is subjected to same process of scanning and labeling. But labeling is done as 2, depicting them as pixels of second component. This procedure is done until no more pixels of value 1 are present. This concludes that all the pixels have been labeled.

Figure 2(b) shows the result of applying connected component analysis by scanning the connected pixel neighbors only in 4 directions. Figure 2(c) shows the same process done by examining neighbors in 8 directions. This causes the pixels labeled 2 and 3 to get merged as 2 as pixels in (3, 6) and (4, 7) are connected in this case diagonally[13].

For each connected component found, they are labeled with running count. The final value used for labeling, gives the count of the connected components found from the extracted license plate.

The labeled components are then enclosed by bounding boxes. The parameters of the bounding box which includes the co-ordinates of upper left corner, its height, width and area are also stored. Using the parameters of the boxes, they are cropped from the extracted license plate and are resized to a standard size of 24x42. Thus the characters are segmented and are stored for the next step.

3.4 Character Recognition

The purpose of this step is to recognize the segmented characters and to output the license plate information. This is done by matching the segmented character and templates stored in memory, using normalized cross correlation calculation.

Normalized cross correlation will result in higher values where the images are related and lower or negative values for images which are not related. Normalized cross correlation is calculated by:

$$\frac{1}{n}\sum x,y\frac{(f(x,y)-\overline{f})(t(x,y)-\bar{t})}{\sigma_f\sigma_t}$$

Where, *t (x,y)* is the template image

- *f (x,y)* is the segmented character
- '*n*' is the number of pixels in t (x,y) and f (x,y)
- σ_f is the standard deviation of f
- $\overline{f}$ is the average of f.

During character recognition phase, for each segmented character, normalized cross correlation is calculated between the segmented character and all templates stored in the database. The template, with which the calculation results in maximum value, means that the template and the segmented character are closely related. So, it is marked as its matching template. Thus, the character gets recognized.

The numbers, characters which are to be recognized are stored in a database. But, storing only them cannot help in recognizing some anonymous and unimportant symbols present in the license plate. Those symbols are called non-characters. For recognizing such non-characters, those symbols should also be stored in database such that, the recognition of which should result in a null classifier.

Thus this character recognition phase helps in recognizing all the characters segmented, irrespective of their font style and language.

4. Experimental Results

The performance was tested using 30 images and the efficiency is analyzed for each step of the process. The test images include Indian vehicles and foreign vehicles. The analysis is shown in Table 1.

In the images, license plates were detected by detecting the edges by Sobel edge detection followed by certain morphological operations to remove smaller edges detected other than that of license plate. The analysis shows that the images taken in real time, when passed on as input to this step resulted in an image with only the extracted license plate. For 30 test images, the license plate extraction phase succeeded in extracting license plates

Table 1. Test results for various

PROCESS	TOTAL IMAGES TESTED	SUCCESS	FAILED	SUCCESS RATE (%)	CUMULATIVE SUCCESS RATE (%)
LICENSE PLATE EXTRACTION	30	28	2	93.33	93.33
CHARACTER SEGMENTATION	28	26	2	92.85	86.67
CHARACTER RECOGNITION	26	25	1	96.15	83.33

from 28 images, leading to 93.33% efficiency. The license plate detection failed in cases only where the pictures were taken from distance and images were of lower quality as they cause the system to fail in detecting edges accurately.

The segmentation of characters in license plate was done by connected component analysis and labeling them, followed by cropping the components labeled. This step uses the image with the extracted license plate as input and resulted with the segmented characters as output, after connected component analysis. 28 images succeeded in previous step were passed to character segmentation phase. Segmentation of characters was successful for 26 images. This phase failed only in cases where the characters were so close to the neighboring characters, making it not to be segmented clearly and incorrect labeling of two characters into a single one, as they are so close.

Segmented characters were then recognized by template matching in the next phase. This was done by calculating normalized cross correlation between the segmented character and each template stored. This is done for each segmented character. The template with which the calculation resulted in a maximum value of normalized cross correlation was recognized as the matching character. The segmented characters resulted from previous phase were passed to this step and the outcomes were the recognized character for each segmented character found after template matching. Character recognition failed only in cases where segmentation of characters as individual ones had failed. Thus the system achieved an overall success rate of 83.3%.

5. Conclusion

Automated License Plate Recognition system helps to retrieve the license plate information of a vehicle from an image acquired from a video using hardware sensors. License plates are extracted by detecting edges using Sobel edge detection technique and subjecting the result to morphological operations followed by connected component analysis to segment the characters. Those characters are then recognized by template matching using normalized correlation measure, with a higher efficiency. The system can be enhanced to recognize bent license plates and license plates with broken characters.

6. References

1. Kimio T, Natarajan G, Hideki A, Taichi K, Nanao K. Higher involvement of subtelomere regions for chromosome rearrangements in leukemia and lymphoma and in irradiated leukemic cell line. Indian Journal of Science and Technology. 2012 Apri; 5(1):1801–11.
2. Cunningham CH. A laboratory guide in virology. 6th ed. Minnesota: Burgess Publication Company;1973.
3. Sathishkumar E, Varatharajan M. Microbiology of Indian desert. In: Sen DN, editor. Ecology and Vegetation of Indian Desert. India: Agro Botanical Publishers; 1990. p. 83–105.
4. Varatharajan M, Rao BS, Anjaria KB, Unny VKP, Thyagarajan S. Radiotoxicity of sulfur-35. Proceedings of 10th NSRP; India. 1993. 257–8.
5. 01/01/2015. Available from: http://www.indjst.org/index.php/vision
6. Hsu GS, Chen JC, Chong YZ. Application-oriented license plate recognition. IEEE Transactions on Vehicular Technology. 2013 Feb; 62(2):552–61.
7. Du S, Ibrahim M, Shehata M, Badawy W. Automatic License Plate Recognition (ALPR): A State-of-the-Art Review. IEEE Transactions on Circuits and Systems for Video Technology. 2013 Feb; 23(2):311–25.
8. Lydia Caroline M, Vasudevan S. Growth and characterization of pure and doped bis thiourea zinc acetate: Semiorganic nonlinear optical single crystals. Current Applied Physics. 2009 Sep; 9(5):1054–61. ISSN: 1567-1739.
9. Anagnostopoulos CNE. License plate recognition: A brief tutorial. IEEE Transactions on Transportation Systems Magazine. 2014; 6(1):59–67.
10. Lydia Caroline M, Kandasamy A, Mohan R, Vasudevan S. Growth and characterization of dichlorobis l-proline Zn(II): A semiorganic nonlinear optical single crystal. Journal of Crystal Growth. 2009 Feb; 311(4):1161–5. ISSN : 0022-0248.
11. Nagarajan C, Madheswaran M. Experimental study and steady state stability analysis of CLL-T series parallel resonant converter with fuzzy controller using state space analysis. Iranian Journal of Electrical and Electronic Engineering. 2012; 8(3):259–67. ISSN: 1735-2827.
12. Solanki R, Rai RK, Raikwar T. The Automatic License Plate Recognition (ALPR). International Journal of Engineering Research and Applications. 2013 Nov-Dec; 3(6):304–10.
13. Parthasarathy R, Ilavarasan R, Karrunakaran CM. Antidiabetic activity of Thespesia Populnea bark and leaf extract against streptozotocin induced diabetic rats. International Journal of Pharm Tech Research. 2009 Oct-Dec; 1(4): 1069–72. ISSN: 0974-4290.
14. Patel A, Patel KR. An introduction to license plate detection system. International Journal of Engineering Research and Applications. 2014 Jan; 4(1):216–22.
15. Gilly D, Raimond K. License plate recognition - A template

matching method. International Journal of Engineering Research and Applications. 2013 Mar-Apr; 3(2):1240–5.

16. Sudhakar Babu G, Chandra Sekhara Reddy K. Automatic license plate recognition system. International Journal of Engineering Research and Applications. 2013 Jul-Aug; 3(4):870–6.
17. Poongothai S, Ilavarasan R, Karrunakaran CM. Simultaneous and accurate determination of vitamins B1, B6, B12 and alpha-lipoic acid in multivitamin capsule by reverse-phase high performance liquid chromatographic method. International Journal of Pharmacy and Pharmaceutical Sciences. 2010 Oct; 2(S4):133–9. ISSN: 0975 – 1491.
18. Kranthi S, Pranathi K, Srisaila A. Automatic number plate recognition. International Journal of Advancements in Technology. 2011 Jul; 2(3):408–22.