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A Review on Automatic Number Plate Recognition System

Author: Keerti Puloria[1], Mr. Sachin Mahajan[2]

PG Scholar, CSE Department, Jawaharlal Institute of Technology, Borawan (M.P.)[1], HOD of IT Department, Jawaharlal Institute of Technology, Borawan (M.P.)[2]

E-mail: kpuloria@gmail.com[1], er_sachin1980@yahoo.com[2]

ABSTRACT

Number plate recognition was invented in 1976 at the Police Scientific Development Branch in the UK. It is a mass surveillance method that uses optical character recognition on images to read vehicle registration plates. They can use existing closed-circuit television or road-rule enforcement cameras, or special cameras specifically designed for the task. Different stages are involved in Automatic Number Plate Recognition (ANPR) System. Different author introduce different techniques for ANPR. ANPR is a real life application. It has to be quickly and successfully process license plates under different environmental conditions, such as indoors, outdoors, day or night time. In these review paper we are showing different techniques used for ANPR.

Keywords

Pre-processing, character segmentation,character recognition.

1. INTRODUCTION

In the simplest of terms, Automatic Number plate recognition (ANPR) is a form of automatic vehicle identification. It is an image processing technology used to identify vehicles by only their license plates. ANPR plays a major role in monitoring of traffic rules and maintaining law enforcement on public roads. A number plate is the unique identification of vehicle and ANPR is design to locate and recognize the license plate of a moving vehicle automatically. It has a wide range of applications for example they are used by various police forces and as a method of electronic toll collection on pay-per-use roads and cataloging the movements of traffic or individuals, security control of restricted areas, parking lots management. Since the license number is the primary, most widely accepted, human readable, mandatory identifier of motor vehicles. ANPR provides automated access of the content of the number plate for computer systems managing databases and processing information of vehicle movements. ANPR involves the use of specialized cameras and software that recognize a license plate, capture an image of the license plate, and interpret the characters of the license plate into data that may then be used for one or more purposes. ANPR technology tends to be region-specific, owing to plate variation from place to place.

ANPR consist of following steps:-

a) Vehicle image capture
b) Preprocessing
c) Number plate extraction
d) Character segmentation and
e) Character recognition.

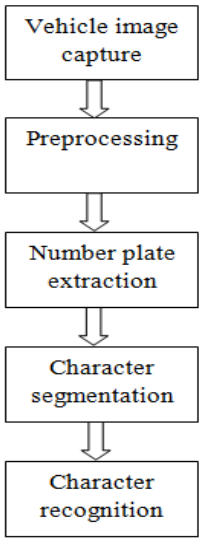

Figure 1:- Steps of ANPR System

Presently number plate detection and recognition processing time is less than 50 ms in many systems. The success of fifth step depends on how second, third and fourth step are able to locate vehicle number plate and separate each character. These systems follow different approaches to locate vehicle number plate from vehicle and then to extract vehicle number from that image.

2. Literature Review

This section includes the work already done on this system by various researchers using different methodologies and algorithms. Following is the brief description of some of them:

Car Plate Recognition Using the Template Matching Method is proposed by M.I.Khalil [15]. Generally, LPR system consists of 4 modules: Image acquisition, licensed plate extraction, segmentation & recognition of individual character. But template matching method does not need the "segmentation" process of input image. After the license plate extraction phase, INFORMATION RECOGNITION PHASE (IPR) is applied. For this phase "moving window technique" is used. To recognize the image the country name, the license plate image is loaded as main image. Then the first image entry of country image set is loaded as an object. The moving window technique is applied to detect that object within the image. If answer is "YES" then the name of country corresponding to country name is retrieved from the country names table. And if answer is "NO" then the next country name image is loaded as the object & this procedure is repeated till the end of the characters.

An Efficient Method of Vehicle License Plate Recognition Based on Sliding Concentric Windows and Artificial Neural Network is proposed by Kaushik Deba, Md. Ibrahim Khana, Anik Sahaa, and Kang-Hyun Job [16]. In this system they are using segmentation technique named as sliding concentric windows(scw).this method helps is analyze road images which are often contain vehicles And extract license plate from natural Properties by finding vertical and horizontal edges from vehicle region. On the Basis of a novel adaptive image segmentation technique is for detecting candidate region and Color verification for candidate region by using HSI color model on the basis of using hue and intensity in HSI colour model verifying green and yellow LP and white LP, respectively. Mainly there focus on artificial neural network (AAN) new algorithm which is based on Korean number plate system. If we try to follow they diagram above you will get clear idea about who this system working taking place. How the candidate region selection taking place and how grey image conversion taking in there.

A simple horizontal scanning of the image looking for the most repeating brightness changes is the method applied by Kong *et. al*. [17]. A number plate always has significant number of brightness changes due to the transition from the character to background and vice versa. Several image transformation techniques have been used in number plate detection. Among the techniques, Hough transform implemented by Duan *et. al*. [18] yields a satisfactory result. But their method has high computational power and so it is not suitable for real time applications. Vladimir Shaprio *et al*, [19] in their approach deals with stages of preprocessing which involves vertical edge detection and rank filtering. With this preprocessing they obtained a vertical projection of the number plates and detected the horizontal strip loosely locked on the plate and clipped them from the image. The skewed portion is detected and is deskewed. The characters are then segmented and recognized.

3. Vehicle Image Capture

The first step i.e. to capture image of vehicle looks very easy but it is quite exigent task as it is very difficult to capture image of moving vehicle in real time in such a manner that none of the component of vehicle especially the vehicle number plate should be missed. For this purpose existing closed-circuit television or road-rule enforcement cameras, or special cameras specifically designed for the task.

4. Preprocessing

This step is essential to enhance the input image and making it more suitable for the next processing steps. Several pre-processing algorithms for ANPR systems are discussed below.

In [1] Otsu binarization method is used for preprocess the image. The acquired image is segmented into several sub-regions. For each sub-region, threshold value is calculated. According to Anagnostopoulos et.al., [2], pre-processing is performed to detect the Region of Interest (ROI) even in the ambient illumination conditions. It is done using image masking, binarization with Sauvola method. In Sauvola method, locally adaptive thresholding is used to convert a gray scale image to a binary image. The value of threshold mainly depends on the local statistics like range, variance and surface fitting parameters. In the case of badly illuminated areas, calculated threshold value will be low.

Figure 2:- Output of Otsu's Algorithm

Niblack"s algorithm is used for binarization. Niblack"s algorithm provided robust thresholding in the presence of shadows and other image defects [3]. It also provide better result as compare to Otsu"s algorithm, But it takes more processing time as compare to Otsu"s algorithm.

Figure 3:- Output of Niblack"s Algorithm

According to Chang et al, [4], binarization is performed mainly for two purposes: to highlight characters and to suppress background. While doing the binarization some important information from the images will be lost, so they employed a variable thresholding technique proposed by Nakagawa and Rosenfeld [4]. In this technique, a local optimal threshold value is determined for each image pixel so as to avoid problem originating from non-uniform illumination. Although locally adaptive thresholding method cannot completely compensate the loss of information, it at least preserves the information that may be lost when using a constant binarization method.

According to T.Duan et.al., [5], pre-processing is performed to enrich the edge features. The algorithms used at this stage are graying, normalizing and histogram equalization. Histogram equalization is used to improve the contrast of image, which can be used to improve the results of edge detector. Locally adaptive thresholding is used for binarization.

In [6], a global threshold value is chosen instead of an adaptive one. To minimize the processing time, the original image is downsampled to 120 columns by preserving the original aspect ratio. G.Sun et al., in [7] divided the pre-processing task into luminance adjustment and image enhancement. These two tasks are achieved by changing luminance curve and top-hat transform respectively. Main advantage of gray scale top hat transform is that it enhances the hot region by differentiating the front and background while weakening the other regions at the same time. Fig. 4 shows the result of top-hat transform.

Figure 4:- Result of Top-Hat Transform

5. Number Plate Extraction

In this stage, the location of the license plate is identified and the output of this stage will be a sub-image that contains only the license plate. This is done in two main steps.

a. Locating a large bounding rectangle over the license plate.

b. Determining the exact location of the license plate.

In the following sections common number plate extraction methods are explained.

Edge detection is fundamental method for feature detection or feature extraction. In general case the result of applying edge detection of algorithm is an object boundary with connected curves. It becomes very difficult to apply this method to complex images as it might result with object boundary with not connected curves. Different edge detection algorithm / operators such as Canny, Canny-Deriche, Differential, Sobel, Prewitt and Roberts Cross are used for edge detection.

In [6], vertical edge detection method is utilized for locating the LP. So Robert's edge detector is used to emphasize the vertical edges. There will be many abrupt intensity changes but a cluster of 10-15 sharp intensity changes is considered as plate zone. Image is convolved with horizontally oriented rank-filter of M×N pixels. This leads to a bright-elongated spot of ellipsoidal shape in the plate's area. The last step is horizontal projection. Fig. 5 illustrates the LPD used in [6].

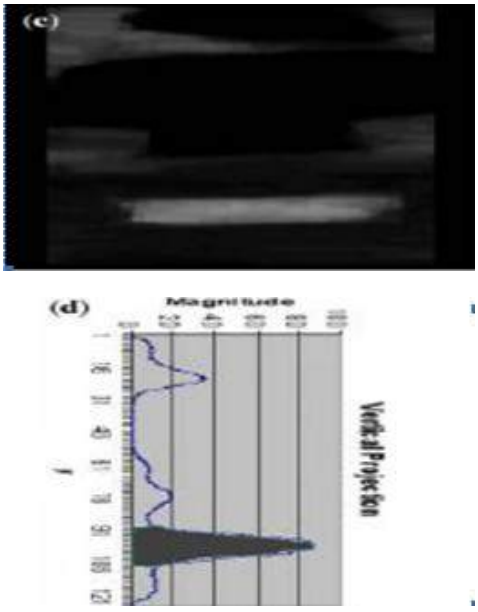

Figure 5:- (a) Original Image (b) Vertical Edge Map (c) Rank Filtered Image (d) Vertical Projection [6]

Hough Transform is a feature extraction technique initially used for line detection. Later on it has been extended to find position of arbitrary shape like circle or oval. The original algorithm was generalized by D.H. Ballard [8].

Mathematical morphology is based on set theory, lattice theory, topology, and random functions. It is commonly applicable to digital image but can be used in other spatial structures also. Initially it was developed for processing binary images and then extended for processing gray scale functions and images. It contains basic operators such as Erosion, dilation, opening, closing.

Blob detection is used to detect points or regions that differ in brightness or color as compared to surroundings. The main purpose of using this approach is to find complimentary regions which are not detected by edge detection or corner detection algorithms. Some common blob detectors are Laplacian of Gaussian (LoG), Difference of Gaussians (DoG), Determinant of Hessian (DoH), maximally stable extremal regions and Principle curvature based region detector.

In [9], [10] and [11] Connected Component Labelling (CCL) is used for LPD. CCL scans the image and labels the pixels according to the pixel connectivity. There are two types of connectivity:-4 and 8 connectivity. 4-connectivity is used for only north and west neighbour of current pixel. And 8-connectivity is used for North-East, North, North-West and West neighbour of current pixel. In [9], a feature extraction algorithm is used to count the similar labels to distinguish it as a region. The region with maximum area is considered as a possible license plate region and this region is forwarded to the segmentation process. But in [10], two detection methods are performed. One is detection of white frame and another one is detection of black characters. White frame is detected using CCL technique and it is sensitive to the edges. So if the frame is broken, the LP cannot be located properly. To determine the candidate frames, aspect ratio of the LP, height and width of characters have to be known. Further, the penetration times through the midline of the large numerals in the LP is also calculated for candidate frame selection.

In [4], fuzzy logic is used to locate LP. The author framed some rules to explain about the LP and gave some membership functions for fuzzy sets - “bright”, “dark”, “bright and dark sequence”, “texture” and “yellowness” to obtain the horizontal and vertical plate positions. But this need is very sensitive to the LP color and brightness. It also takes longer processing time compared to conventional color based methods.

In [12], for faster detection of region of interest (ROI) a technique called sliding concentric window (SCW) is developed. It is a two step method contains two concentric windows moving from upper left corner of the image. Then statistical measurements in both windows were calculated based on the segmentation rule which says that if the ratio of the mean or median in the two windows exceeds a threshold, which is set by the, then the central pixel of the windows is considered to belong to an ROI. The two windows stop sliding after the whole image is scanned. The threshold value can be decided based on trial and error basis.

6. Character Segmentation

Character segmentation is the method which separates character present in the image. The output of this stage is a set of monochrome images for each candidate character in plate. Almost all the papers that had been surveyed [1], [9] and [11] used horizontal and vertical projection to segment the characters. Fig. 6 shows the result of character segmentation used in [11]. In [13], vertical and horizontal scanning is used to dig out the characters. Vertical scanning will scan the image vertically from [0, 0] to [height, width] which is executed on column by column basis. Width between the first and last column is computed and each character is separated from the plate background and stored in separate array so that it is used for horizontal scanning. Horizontal scanning is performed to eradicate the extra upper and lower region from the image.

CCA is very useful technique for processing binary image. In [14] horizontal and vertical correction and image enhancement are performed as pre-processing steps for character segmentation. CCA is used in horizontal and vertical correction. After performing these steps plate is transformed to black characters / white background and then resized to 100 X 200. Then all the characters are segmented to the unique size of 32 X 32.

A variety of methods like blob coloring, peak-to-valley method are also suggested for character segmentation. However, these methods are not suitable for Indian number plates since they do not provide good results in cases where the characters are overlapping and are also time consuming.To have reliability and time-optimization, a new „Image Scissoring" algorithm is developed. In this algorithm, the number plate is vertically scanned and scissored at the row on which there is no white pixel (i.e., a blank row) and the scissored area is copied into new matrix. This scanning procedure proceeds further in search of a blank row and thus different scissored areas are obtained in different matrices. Indian number plates can have either single or double rows. Hence, maximum two matrices must co-exist. To discard false matrices, heights of the matrices are compared. If the height of any of matrix is less than 1/4th of the height of tallest matrix, then the prior matrix is discarded. The same procedure is repeated horizontally on each matrix and using width as a threshold, individual characters are segmented (Fig.6).

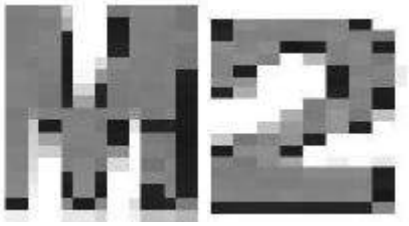

Figure 6:- Sample Output of Image Scissoring

7. Character Recognition

After segmenting the characters, the next step is character recognition. There are several methods have been proposed for character recognition. Some of them are discussed below.

Artificial Neural Network (ANN) is one of the method used to recognize character. A neural networks based on Kohonen's self-organized feature maps can be implemented to handle noisy, deformed, broken, or incomplete characters acquired from LPs that were bent and/or tilted with respect to the camera. This method focused on accuracy at the cost of increased complexity and execution speed. The success rate for character identification, in a large set of 1061 LPs in various viewpoints (combinations of angle and distance) is around 95.6%.

To avoid misclassification of similar character pairs (8, B), (0/D), and (O/D), Chang et.al., pre-defined an ambiguity set that contains the pairs of them as classified characters. During character recognition, once an unknown character is classified as one of the characters in the ambiguity set, an additional minor comparison between the unknown character and the classified character is performed. The comparison then focused only on the non ambiguous parts.

Huang et al., uses back propagation neural network (BPNN) for recognizing characters. The 26 vertical and 50 horizontal projections of the normalized 26×50 pixel license plate image are fed into 76 input nodes of BPNN. This network also comprises of 85 hidden nodes and 6 output nodes. Most license plate characters are successfully recognized by BPNN. However, characters such as B and 8, 1 and I, 8 and B, and O and D may be hard to distinguish using the neural network. The most significant difference between the characters O and D lies at their upper and lower left corners as shown in Fig. 7 a, b. A straight line is posted to the character as the base line to respectively accumulate the number of white pixels at the upper and lower left corners. The recognition rate is 97.3%.

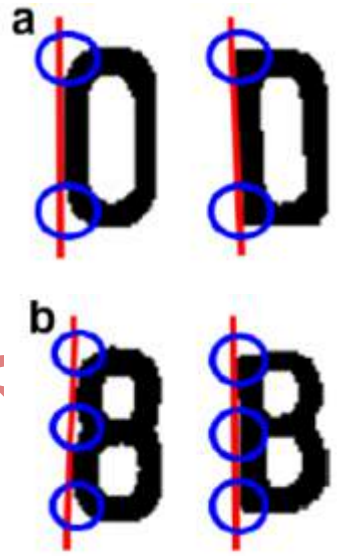

Figure 7:- Features of Similar Characters

Support Vector Machine (SVM) is used for character recognition. Before training and testing, features are extracted using Local-Direction Contributivity Density (L-DCD) and Global-Direction Contributivity Density (G-DCD). Compared to neural networks, SVM has less misclassification rate.

Template matching is useful for recognition of fixed sized characters. It can be also used for detection of objects generally in face detection and medical image processing. It is further divided in two parts: feature based matching and template based matching. Feature based approach is useful when template image has strong features otherwise template based approach can be useful.

Probabilistic Neural Networks (PNNs) are introduced in the neural network literature by Anagnostopoulos *et al.*. These types of neural networks can be designed and trained faster, as the hidden-layer neurons are defined by the number of the training patterns and are only trained once. PNN for LPR is first introduced in an early version of an LPR system where two PNNs, i.e., one for alphabet recognition and the other for number recognition, are trained and tested. The recognition rates reported in the literature are very encouraging when PNNs are trained and tested in

noisy, tilted, and degraded patterns. The Optical Character Recognition (OCR) system is a two layer PNN with a topology of 108-180-36 nodes, whose performance for entire plate recognition reached 89.1%.

8. Conclusion

Automatic Number Plate Recognition system has become a main key of many traffic related applications, e. g. the road traffic monitoring, the traffic analysis, the parking lots access control etc. Accurately detecting the number plate from a vehicle image, extracting the numbers and characters from number plate, and quickly recognizing the number are considered to be the most important stage of ANPR system. They significantly affect the recognition accuracy and processing speed of the entire system.

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