

Automatic Number Plate Recognition (ANPR)

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Abstract – Automatic Number Plate Recognition (ANPR) is the technology which is used to identify the vehicle number plate by capturing images. Mostly this technology is being increasingly used in traffic control and law enforcement applications. This paper reviews the current state of the art in ANPR including image acquisition, feature extraction and recognition and as well as in deep learning approaches. It also examines the challenges associated with ANPR, including varying image quality, plate designs and font types. Finally, it discusses the potential applications of ANPR and the implications for public safety and security. The paper includes with a discussion of future research directions, which involves the development of robust algorithm for handling varying image quality, improved recognition techniques to deal with license plate of different and the integration of ANPR with other technologies, such as facial recognition.

Keywords- Automatic Number Plate Recognition (ANPR), Character Segmentation, Image Segmentation, Number Plate, Optical Character Recognition.

I- INTRODUCTION

In last few years, ANPR or license plate recognition (LPR) has been one of the useful approaches for vehicle surveillance. It can be applied at public places like traffic areas, toll gates and Automated vehicle parking system. ANPR algorithms are generally divided in four steps: (1) Vehicle image capture (2) Number plate detection (3) Character segmentation (4) Character

recognition. It is shown in fig (1). the first step is 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. Presently number plate detection and recognition processing time is less than 50 ms in many systems. The success of fourth step depends on how second and third 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. Most of the ANPR systems are based on common approaches like artificial neural network (ANN), Probabilistic neural network (PNN), Optical Character Recognition (OCR), etc, Least Square Method (LSM), online license plate matching based on weighted edit distance and color-discrete characteristics. A case study of license plate reader (LPR) is well explained. Some authors focus on improving resolution of the low-resolution.

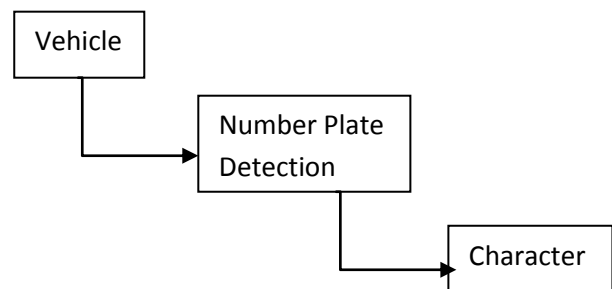


Fig1- Automatic Number Plate Recognition(ANPR)

II- METHODOLOGY

1.2 Scope of this paper

As it is not possible to judge that which approach is better, different papers, which are mentioned in the steps in the above figure, are surveyed and categorized that are based on the methodologies in different approaches.

For each approach whenever available parameters like speed, accuracy, performance, image size and platform are reported. Commercial product survey is beyond the scope of this paper as sometimes these products claim more accuracy than actual for promotional purposes. Remainder of this paper is divided as follows: Section 2 contains survey of different techniques to detect number plate. Character segmentation methods are reviewed in section 3 and section 4 contains discussion about character recognition methods. The paper concludes with the discussion of what is not implemented and what kind of research is possible in ANPR.

2. Number Plate Detection

Most of the number plate detection algorithms are based on different algorithms to fall in more than one category. To detect vehicle number plate following factors should be considered:

- Plate size: a plate can be of different size in a vehicle image.
- Plate location: a plate can be located anywhere in the vehicle.
- Plate background: A plate can have different background colors based on vehicle type. For example a government vehicle number plate might have different background than other public vehicles.
- Screw: A plate may have screw and that could be considered as a character.

2.1 Image binarization

As the Image Binarization, it is a process which converts an image to black and white. By using in this method different thresholds were chosen to classify particular pixels as black and white. There was a problem is that how to choose the correct threshold value for particular image. Sometimes it becomes very difficult or impossible to select optimal threshold value. Adaptive Thresholding can be used to overcome this problem. A threshold can be selected by user manually or it can be

selected by an algorithm automatically which is known as automatic thresholding.

2.2 Edge detection

Edge detection method is used to detect the edge curves. The object that is placed in front of the camera, it then detects the edge. Many algorithms are used to create an boundary curve. 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.

2.3 Blob detection

Blob detection is used to detect points or regions that are differ as like in colors that are compared to surroundings. Mainly this approach is used to find Complimentary regions that are detected by edge detection algorithm. Some of the common blob detectors are Laplacian of Gaussian (LoG), Difference of Gaussians (DoG), Determinant of Hessian (DoH), maximally stable external regions and Principle curvature based region detector.

2.4 Connected components analysis (CCA).

Connected components analysis (CCA) is also known as blob detection extraction approach to uniquely the label subsets of connected components of given based heuristics. It scans the binary image and the label pixels as per the connectivity conditions of current pixels such as North-East, North-West and west of the current pixels this connectivity is called as (8 – connectivity). And 4 – connectivity is only used for north and west neighbours of current pixel. As this algorithm gives the better performance that is useful for automated image analysis.

2.5 Related work in number plate detection

The methods discussed in preceding sections are common methods for plate detection. Apart from these methods, various literature discussed method for plate detection. As most of the methods discussed in these literatures use more than one approach, it is not possible to do category wise discussion. Different number plate segmentation algorithms are discussed below.

SCW based system is presented in [4] for locating Korean number plate. After applying SCW on vehicle image authors used HSI color model for color

verification and then tilt was corrected by using least square fitting with perpendicular offsets (LSFPO). The distance between camera and vehicle varies from 3 to 7 meters

To detect multi-style number plate a configurable method is proposed in [10]. For detecting different style of number plates, a user can configure the algorithm by changing parameter value in the number plate detection algorithm. The authors define four parameters mainly:

- Plate rotation angle- to rotate number at certain angle plate if it is skewed which is shown in fig. 2(a).
- Character line number – to determine whether characters are spanned in more than one line or column as shown in fig. 2(b). The algorithm works for maximum three lines.
- Recognition models – to determine whether number plate contains alphabets only, alphabets and digits or alphabet, digits and symbols.
- Character formats – To classify the number plate characters based on their type. For example, Symbols can be represented as S, Alphabets can be represented as A and digits can be represented as D. So the number in fig.2, can be represented as AADAADDDDD.



(a) Skewed image (b) Number plate with lines

Fig.2.-Vehicle number plate with two parameters.

Table 1- Number plate detection rate and image size

Ref	Image size	Success Rate (in %)
[1]	1024 X 768	96.5
[10]	720 X 1280	90.1
[4]	640 X 480	89
[8]	640 X 480	97.3
[12]	640 X 480	97.6
[7]	648 X 486	96.4

2.6 Discussion

Most of the literatures, the number plate segmentation algorithms work in restricted conditions like illumination, number plate shape (generally rectangle), size, distance from camera and vehicle and color. It should be noted that only few algorithms work for real-time video image of a number plate, otherwise static image of number plate is remitted to ANPR for further processing. In Table 1, different plate segmentation detection success rate against plate resolution of different ANPR is depicted. The systems in which image size and success rate of number plate detections are not mentioned, are not included in Table 1. It is evident that number plate detection rate affects character segmentation and character recognition which in turn affects overall recognition rate.

In order to proceed with character recognition, further image processing in the form of character segmentation is required, which is discussed in the next section.

III - CHARACTER SEGMENTATION

After locating number plate, characters are examined for the further process. As with the plate segmentation there are various methods available for conducting character segmentation.

3.1. Related work in character segmentation

The candidate region is cropped in 78 X 228 pixels are used as bi-cubic interpolation and then to SCW for segmentation. The threshold values used by the authors is 0.7 for optimization of the results. After the character segmentation process, each character is resized to pixel size of 9 X 12.

Prathamesh Kulkarni et al. [18] conclude that blob coloring and peak-to-valley methods are not suitable for Indian number plate. The authors proposed image scissoring algorithm in which a number plate is vertically scanned and scissored at the row where there is no white pixel and this information is stored in the matrix. In case of more than one matrix, a false matrix is discarded based on the formula given in this paper. Same process is repeated for horizontal direction by taking width as a threshold.

CCA is an useful technique for processing binary image. 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. In image binarization and connected component labelling methods are used.

Three matrices which are used for storing the location and the binarization numbers in columns and rows is BW respectively. Top and bottom boundaries locations are précised to detect, by vertical projection and thresholding for segment characters.

H.Erdinc Kocer [2] used contrast extension, median filtering and blob coloring methods for character segmentation. Contrast extension is used to make image sharp. As per H.Erdinc Kocer the histogram equalization is a popular technique to improve the appearance of a poor contrasted image. In median filtering unwanted noisy regions are removed. Blob coloring method is applied to binary image to detect closed and contact less regions. In this method, an L shaped template is used to scan image from left to right and top to bottom. This scanning process is used to determine the independent regions by obtaining the connections into four directions from zero valued background. The four directional blob coloring algorithm is applied to the binary coding license plate image for extracting the characters. At the end of this process the numbers are segmented in the size of 28 X 35 and letters are segmented in the size of 30 X 40. Another algorithm based on blob detection is proposed in [7]. The character segmentation process consists of character height estimation, character width estimation and blob extraction. Character height estimation contains three parts: color reverse, vertical edge detection and horizontal projection histogram. Color reverse is used to make color of license plate characters as black by using statistical analysis of edges. Vertical edge detection is used to detect finalized number plate. Sobel mask and image binarization algorithms are used to perform it. Horizontal projection histogram is used to find top and bottom boundary of a character. The distance between upper and lower boundaries is considered as height of a character. Character width estimation contains: image binarization and vertical projection histogram. Image binarization is used to make color as black and white. Vertical projection is used to find gaps between characters. The process is similar as horizontal projection. Blob extraction is a two- step procedure including Blob detection and blob checking algorithms. The blob detection algorithm is an extension of CCA. Blob

checking is used to remove non blob characters from the segmented characters.

3.2 Discussion

With good amount of accuracy the Character segmentation is very important to perform character recognition. Sometimes it is not possible to recognize the character. In some literature of ANPR, character segmentation is not discussed with details. Some methods such as image binarization, CCA, vertical and horizontal projection can produce better results of character segmentation.

IV- CHARACTER RECOGNITION

As discussed in Section 2, character recognition helps in identifying and converting image text into editable text. As most of the number plate recognition algorithms use single method for character recognition.

Table 2 - Character recognition rate with method and type of category.

Ref	Method	Success rate(in %)	Type of Category
[1]	Two layer PNN	89.1	Letters
[8]	Feature salient	95.7	Not reported
[9]	Template matching	Not reported	Letters, digits
[2]	Multi layered perception (MLP) ANN	Not reported	Letter, digits
[3]	Multi layered perception (MLP) ANN	Not reported	Letter, digits
[7]	Open source OCR Tesseract	98,7	Letter, digits
[4]	BP neural work	Not reported	Korean Letters, digits
[6]	PNN	96.5	Letter, digits
[5]	BP neural network	93.5	Letter, digits

V- CONCLUSION

5.1 Future work

ANPR can be further used for vehicle model identification, vehicle owner identification, traffic control, vehicle speed control, vehicle location tracking and vehicle control system. It can be further extended as multilingual ANPR to identify the language of characters automatically based on the training data. It can provide various benefits like traffic safety enforcement, security- in case of suspicious activity by vehicle, easy to use, immediate information availability- as compare to searching vehicle owner registration details manually and cost effective for any country. For low resolution images some improvement algorithms like super resolution [16], [17] of images should be focused. Most of the ANPR focus on processing one vehicle number plate but in real-time there can be more than one vehicle number plates while the images are being captured. In [1] multiple vehicle number plate images are considered for ANPR while in most of other systems offline images of vehicle, taken from online database such as are given as input to ANPR so the exact results may deviate from the results shown in Table 1 and Table 2. To segment multiple vehicle number plates a coarse-to-fine strategy could be helpful.

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