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Review Methods of Automatic License Plate Recognition: Future Road Map

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Abstract: *At present condition in every country, the identification of owner of vehicle as well as traffic control has becoming the major problem. The owner and vehicle identification becomes necessary to track the user who violates the rules of traffic or driving too fast in more people's area. With the use of manual traffic control process, it is highly impossible to track those owners those are breaking the traffic rules and punish them. Thus to automate this process and catch the real owner of driven vehicle, we need to have computerized system which can able to catch the current activities and able locate the license plate number using different image processing techniques. This automated system of recognizing the license plate number of moving vehicle is called as License Plate Recognition (LRP) system or Automatic Number Plate Recognition (ANPR) system. This system is consisting of four main phases such as image acquisition (capturing image from live cameras), image preprocessing, character segmentation and character recognition. As per the rules of each country, these license plates are having different formats and colors. Therefore, every country should have their own ANPR system in place as per their license plate rules. Right now this system is implemented in US and UK road conditions, but still not done any real time work for Indian roads. In this paper our aim is to present the review of detailed processes and methods presented for LRP system. LRP system is based completely on image processing.*

Key Word: *License Plate, License plate recognition, image acquisition, image preprocessing, character segmentation, character recognition.*

I. Introduction

In every country, for each vehicle one unique number is allocated for the identification of that vehicle and its owner. The systems like ANPR or LPR playing very crucial role in real life applications such as parking payment, traffic controlling, catching the vehicle which breaks the traffic rules, stolen cars etc. The adaptations of such automated systems are very advantageous as well as reduce many overheads as compared to traditional manual systems. The process of LRP is consisting of complex tasks such as preprocessing, license plate detection, character segmentation and character recognition. This process becomes more complex while working with number plate images at different angels and noises. As this process is usually works under the real life environments, thus this needs to be fast as well as accurate. Many of the LPR system are minimizing the complexity by putting some constraints over the distance and position of camera for vehicle and its inclined angles. If we consider different angles and views of cameras, then the recognition rates increases significantly and hence the LPR system becomes stronger. With this addition there some other features using which we can increase the accuracy of LPR system. In this paper we are presenting the survey over LPR or ANPR system, and explaining it's every step with different methods. In section II we are discussing the different phases included for LPR with survey of different methods presented for them.

II. Survey of License Plate Recognition Methods

In this section we are taking the detailed review of complete automated system for vehicle number recognition. In this section we are presenting each step of this system and different methods used for it. Figure 1 is showing entire stages of this system.

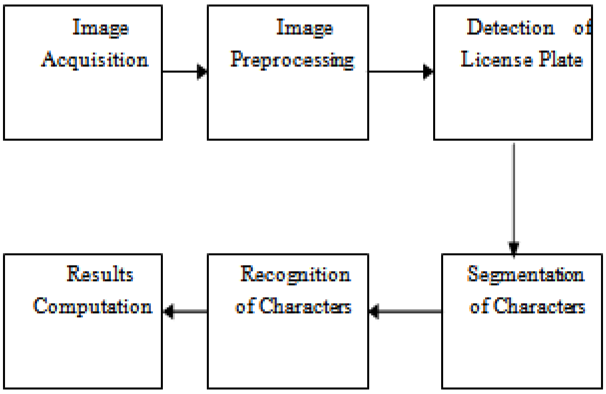

Figure 1: Automatic License Plate Recognition System Architecture

2.1 Image Acquisition: This is the first phase of LPR system in which the input is given to the next phases. These images are taken directly from the videos or cameras. The quality of such images is based on the quality of cameras. Hence it's always better if we have good quality cameras in place for capturing the images live. The images are always in different sizes, different orientations and directions etc.

2.2 Image Preprocessing: This is the phase in which the quality of input image is improved using the different methods. The preprocessing step is having many methods which are used to improve the images quality, to minimize the shadows, as well as to remove the noises from images. Due to this process, the accuracy of LPR system is improved. In this section we study the different algorithms those are used for preprocessing are discussed.

In [1], Otsu binarization method is used. The acquired image is segmented into several sub- regions. For each sub-region, threshold value is calculated. According to Anagnostopoulos et.al., [4], 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.

According to Chang et al, [5], 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 [5]. 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. In [6], a global threshold value is chosen instead of an adaptive one. To minimize the processing time, the original image is Acquire 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.

According to T.Duan et.al. [9], 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 [11], image de-noising is applied to remove noises in the images. In this procedure, subtle fractures can be linked and tiny abrupt changes can be softened. The main aim of this technique is to prevent the destruction of image edges, to retain the image outline and lines as much as possible, increasing the contrast between the ROI and other regions.

In [10], improved Bernsen algorithm is used to effectively remove the shadows in the image by converting it into a binary image. Improved Bernsen algorithm calculates two threshold values: threshold of the original image and the threshold value of the Gaussian filter applied image. Each pixel of the original image is compared with these threshold values to convert it to a binary image.

Detection of License Plate: Once after the preprocessing step, the next is to detect the license plate from vehicle image. LPs (License Plates) are located by means of horizontal and vertical projections through search window in [1]. If the LP is not found using the above method then the original image is inverted. Since LPs are located at the bottom part of the image, projection histograms are scanned from the bottom to the top so that the height of the LP can easily be identified. After performing the horizontal segmentation, vertical projection is carried out.

In [2], region with dense vertical edges is segmented as a candidate plate which is known as ROI. In the location procedure, vertical Sobel edge features are primarily extracted. Then a skeleton extraction algorithm on edge map is performed. There is a possibility that dense pixels are text region and isolated edge pixels are often noises. So density based region growing method is used to locate candidate LP regions.

In [3], [10] and [4] 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. In [3], 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], after the successful CCL on the binary image, measurements such as orientation, aspect ratio, Euler number for every binary object in the image are calculated. Criteria such as orientation < 35 degrees, 2 < aspect ratio < 6 and Euler number > 3 are considered as candidate plate regions in [4]. But this method does not guarantee that LP with dark background and white characters will be successfully detected.

In [5], fuzzy logic is used to locate LP. The author framed some rules to explain about the LP and gave some membership functions for fuzzy 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 [6], vertical edge detection method is utilized for locating the 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. The last step is horizontal projection.

In [11], after applying the Sobel edge detection method certain rules have been applied to locate the LP area. The first criterion is to find the column range of LP. Second step is to detect row range. After these steps, license plate will be obtained. So, to eliminate some candidate, the pseudo license plate aspect ratio of each candidate region is calculated.

In [9], a combination of Hough transform and counter algorithm is applied to detect the LP region. First the counter algorithm is applied to detect the closed boundaries of objects. These counter lines are transformed to Hough coordinate to find interacted parallel lines that are considered as LP candidates. Counter and Hough transform method. To filter out the candidate plates, the aspect ratio of the LP and the horizontal cross cuts are used. In the case of number of horizontal cross cuts for 1 row plate is in the range of 4 to 8. For 2 row plate, it is in the range of 7 to 16.

Skew Correction: It is not possible to take pictures without any tilt. So for successful recognition of license plate, tilt correction has to be performed after LPD.

In [6], skew correction is performed using Randon Transform (RT). But this RT method has a large computation cost. So to reduce the cost, RT is replaced by faster Hough transform.

In [9], a new skew correction is developed with high speed of operation, high accuracy and simple structure.

In [10], both the horizontal and vertical correction is done. The left half of the image is scanned and the average height of white pixel is:

Slope=(leftaver-Rightaver)/(nwidth/2)

Where nWidth is the width of the LP

Segmentation of Characters: After detection license plate, the next process is to do the segmentation characters. Character segmentation is the procedure of extracting the characters from the LP image.

Almost all the papers that had been surveyed [1], [3] and [10] used horizontal and vertical projection to segment the characters.

In [8], 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 an$d lower region from the image. In [2], different methods are used for character segmentation. Firstly, a gray-level quantization and morphology analysis are performed to obtain the candidate characters. Operator chosen was (1, 0.2×H) pixels in X and Y orientations where H represents the height of ROI. To improve the segmentation procedure, above mentioned method is combined with binarization method.

Recognition of Character: This is the final step of this system is recognition of characters. Almost all LPR systems are using different types of Artificial Neural Network (ANN). So neural networks based on organized feature maps is implemented in [5] 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%.

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.

Probabilistic Neural Networks (PNNs) are introduced in the neural network literature by Anagnostopoulos et al. [4].

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%.

Huang et al. [1] 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. 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%.

In [10], 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.

In [8], template matching method is used for character recognition. Each segmented character is matched with the stored template. Priority is assigned for each template.

In [8], template matching method is used for character recognition. Each segmented character is matched with the stored template. Priority is assigned for each template. When matching is performed, first the highest priority template is compared and if a match occurs the lowest priority templates are ignored. Number templates are assigned higher priorities because chances of occurrences of alphabets are less than the numbers.

Caner et al. in [3] used a Self Organizing Map (SOM) neural network to identify the characters. An ordinary SOM has the following two layers: 1) an input layer and 2) a computation layer. The computation layer has the processing units. The weight matrix of the SOM is calculated during the learning phase. The hardware designed calculates the hamming distance between the weight matrix of each neuron and the input image and makes a decision on the output character. The recognition rate is 90.93%.

In [6], two types of template matrix or feature vectors are extracted: Object Thinned Representation (OTR) and Characteristics Background Spots (CBS). OTR represents the character shape. CBS reflect the map of the image background within character bounding box. Postpocessor is responsible for refining recognition results by making use of the specific LP context significance. (10)

III. Conclusion and Future Work

In this review paper we addressed that LPR system is consisting of four main steps for identification of owner of vehicle. The first step is camera image acquisition, the quality of this images is depends on the selected of cameras and its features. The next second phase is extraction of license plate from the input preprocessed image. This extraction is basically done based on features like color, boundary, or characters existence. The third step is segmentation of extracted license plate, in this phase characters are extracted using their color information, using labeling or by template matching method. The fourth and final step is recognition of characters which done using template matching or by using the classifiers like fuzzy rules, ANN or SVM. As we discussed all this phases in this review paper, the concept of Automatic license plate recognition is becomes more complex in case there are different angels of vehicle images and different conditions. Thus for the future work we suggest to work on improved LPR in which different conditions as well as angels of vehicles are considered for recognition of license plate of vehicle.

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