An Enhanced System for License Plate Recognition Using Image Processing and Neural Network methods

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***Abstract*—** The automatic number plate reorganization (ANPR) is one of the solutions of such kind of problem. There are different methodologies but it is challenging task as some of the factors like high speed of vehicles, languages of number plate & mostly non-uniform letter on number plate effects a lot in recognition. The license plate recognition system mainly has four stages: image acquisition, license plate detection, character segmentation and character recognition. The license plate recognition (LPR) system have many applications like payment of parking fees; toll fee on the highway; traffic monitoring system; border security system; signal system etc.

***Keywords*—** Automatic License Plate Recognition (ALPR), License plate recognition (LPR), License plate recognition, character recognition, character segmentation, template matching, optical character recognition.

I. INTRODUCTION

License Plate Recognition (LPR) is a technology used to identify vehicles by their license plates using image processing techniques. Automatic License Plate Recognition (ALPR) has lot of real time applications such as automatic toll collection [1], criminal tracking [2], law enforcement related to traffic [3], etc. There exists few systems for vehicle identification based on Radio Frequency Identification (RFID), Wireless Sensor Network (WSN), etc. But, because of the added advantages such as ease of access and installation, cost effective collection of in detail information of vehicles, etc., ALPR based on vehicle images gained much more popularity for the real time intelligent and smart transportation systems, over the other vehicle identification systems.

License Plate Recognition mainly consists of three steps, namely, plate localization, character segmentation and character recognition. Plate localization step finds region of interest from a vehicle image, where the license plate is located. The characters are separated from the located license plate in character segmentation step. Finally, the separated characters are recognized by using a trained model in character recognition step.

Multi-Style License Plate Recognition (MSLPR) is the system which provides an efficient recognition facility for vehicles having license plates with variations in the font styles.

One attempt is made in this paper to develop an efficient MSLPR system using morphological operations in combination with horizontal and vertical edge histogram and Artificial Neural Network (ANN) for Indian vehicles. The proposed MSLPR system is trained and tested with Indian vehicle images from private database.

The rest of the paper is organized as follows. Section II describes the existing work related to LPR. The proposed MSLPR system is described in Section III. Experimental results obtained for proposed MSLPR system are elaborated in Section IV . Finally, the conclusion of the paper is drawn in Section V.

II. RELATED WORK

Many researchers have contributed to solve the problem of ALPR based by proposing different methods and algorithms for plate localization, character segmentation and character recognition, in the past decades.

Most of the researchers have extracted one of the three features for license plate localization namely, edges [4], color [5], [6] and texture [7]. Out of which, edging features in combination with morphological operations are proven to be an efficient features for license plate localization [4], [8], [9]. Projection [10], binarization [11] and global optimization [12] are commonly used character segmentation methods for ALPR by the researchers. Out of which, binarization [11] is the easy and fast method for character segmentation. The techniques used by researchers for character recognition in ALPR can be broadly categorized as learning based techniques and template matching technique. In learning based techniques, researchers have used ANN [13], Probabilistic Neural Network (PNN) [14], Support Vector Machine [15] and cascade classifier [2] for character recognition. ANN is a choice of most of the researches in learning based techniques for character recognition. Template matching is also a popular technique for character recognition because of fast and easy implementation [16], [17]. But, it fails to handle the complex cases in unconstrained environment. Researchers are contributing to improve the robustness of template matching technique. Learning based approach is preferred by most of the researchers over template matching approach for character recognition in ALPR. Karthikeyan and Vinothkumar [18] proposed the LPR system using edge histogram and template matching. Their system is evaluated over a small size private database containing 12

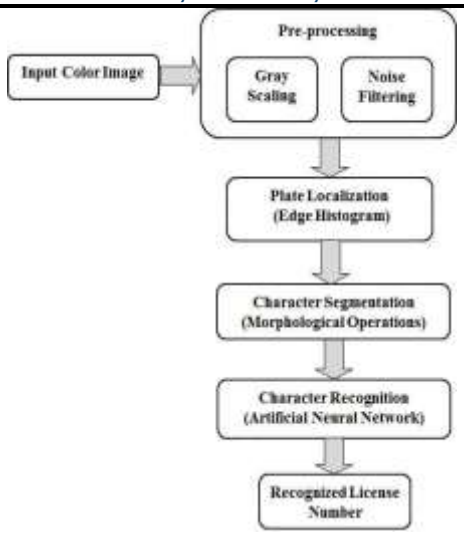

Fig. 1: Framework of Multi-Style License Plate Recognition System

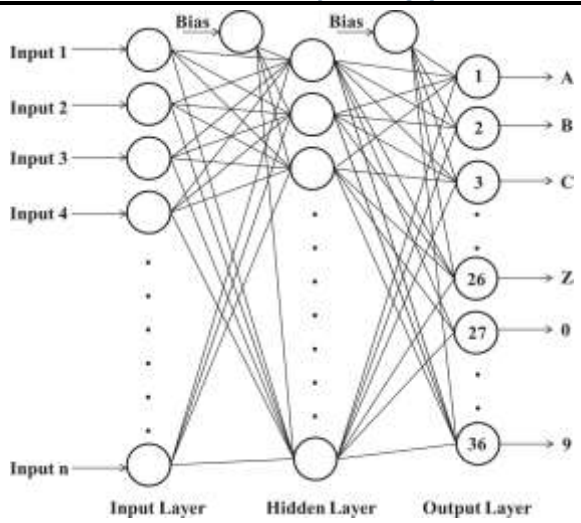

Fig. 2: Artificial Neural Network for MSLPR system.

images of Indian vehicles. They achieved accuracy of 83%, 83% and 75% for extraction of plate region, segmentation of the characters and recognition unit respectively. They achieved overall system accuracy of 80%.

After surveying the existing LPR systems it has been observed that there exists several systems, which deals with LPR with some constrain on font styles. But, there is less work on multi-style LPR system [19], [20], [21]. MSLPR is considered to be a complex problem to deal in real time environment. Hence, one attempt is made in this paper to design a system that deals with three font styles. In this paper, a method based on edge histogram in combination with morphological operations is proposed to improve the accuracy of character segmentation, in comparison with only edge histogram [18]. The character recognition accuracy is improved by using feedforward backpropagation ANN, in comparison with the template matching algorithm [18].

III. Proposed Multi-Style License Plate Recognition System

Fig. 1 shows the framework of Multi-Style License Plate Recognition system. MSLPR system consists of pre-processing, plate localization, character segmentation and character recognition. Each block of proposed MSLPR system is explained in detail as follows.

A. Pre-processing

Vehicle images acquired through camera are mostly color images. Performing the operations on color vehicle images is a complex and time consuming task. In real time applications, the surrounding environment is uncontrolled. Therefore, the captured vehicle images may contain some unwanted noise. Hence, there is a need for pre-processing of the input images.

Pre-processing consists of color conversion of input vehicle images into gray scale images and noise filtering.

The coloured vehicle images contain red, green, blue colour components. Conversion of coloured vehicle images into gray scale images contain black, white and gray values in the range [0-255]. Median filtering is used to remove the unwanted noise in the input vehicle images.

B. Plate Localization

It is an important task to find the location of License Plate in the vehicle image. Plate Localization is done by using morphological operations like dilation, erosion in combination with horizontal and vertical edge histogram. Sobel edge detector is used for detecting edges of license plate, in the proposed system [22].

C. Character Segmentation

After locating the license plate region in the vehicle image, characters on the license plate are segmented by using morphological operations like opening, closing, thinning and connected component analysis. The character segmentation results in binary images of each character in LP region. For Indian vehicles, the characters on the LPs consists of three parts. First part consists of two characters representing the state to which the vehicle is registered. Next part consists of two letters (numbers) representing the sequential number of district in that state. The last part is a 4 digit number unique to each vehicle. A letter is prefixed when the 4 digit number reaches to its maximum value (9999) and then two letters and so on.

D. Character Recognition

After extracting the characters in the form of binary images, Artificial Neural Network (ANN) is used to recognize them. A two layer feedforward backpropagation ANN [23] is used to recognize the segmented characters as shown in Fig. 2. Input layer contains neurons equal to the length of binary image vector of segmented character. Output layer contains 36 neurons equal to number of output characters (A-Z, 26

characters and 0-9, 10 numbers). The remaining parameters of ANN such as number of neurons in the hidden layers, number of epochs, training function, etc. are finalized through experimentation, to obtain the maximum character recognition accuracy.

The steps involved for MSLPR using proposed system are as follows.

1) Let, $L(r, g, b)$ be the input vehicle image to MSLPR system shown in Fig. 1.
2) Perform pre-processing on the input vehicle image $L(r, g, b)$ to get the noise free gray scale image, $L(x, y)$, where $(x, y) \in [0, 255]$.
3) Localize the LP in $L(x, y)$ using morphological operations in combination with horizontal and vertical edge histogram. Let, $I(x, y)$ be the localized LP region.
4) Perform morphological operations on $I(x, y)$ for character segmentation. Let, I_i be the binary images of segmented characters. Where $i = 1, 2, 3..., N$ and N is the total number of segmented characters.
5) Resize I_i to predefined template size 42×24. Let, I_{r_i} be the resized binary image of I_i.
6) Convert I_{r_i} into a vector of size 1008×1. Let, I_{rv_i} be the vector of binary image I_{r_i}.
7) Apply I_{rv_i} to ANN, which is trained over predefined templates, for character recognition.
8) Display the recognized license number.

IV. Experimental Results

Experimentation for the proposed MSLPR system is performed with vehicle images from private database. As there is no standard database available for experimentation, there is need to create the private database. The database consists of 100 vehicle front or rear images in unconstrained environment.

The proposed method is evaluated for most commonly used font styles for Indian vehicle LPs namely, Arial, Courier and Times New Roman. The sample vehicle images for these font styles from the database are shown in Fig. 3.

Fig. 3: Sample vehicle images for different font styles from the database.

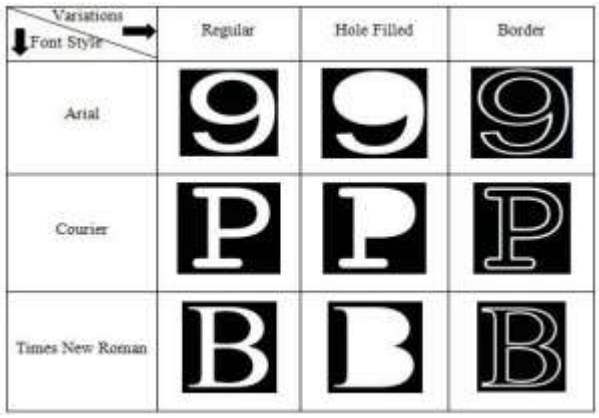

Fig. 4: Sample templates for three font styles with three variations.

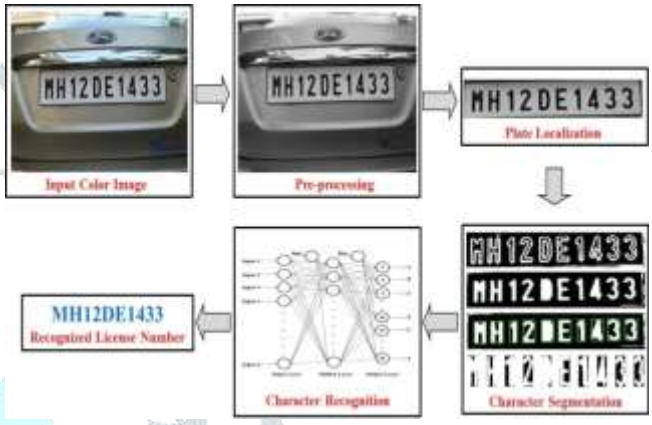

Fig. 5: Steps involved in the proposed MSLPR system.

The binary image templates of predefined size 42×24, are created for 26 alphabets (A-Z) and 10 numbers (0-9) for three font styles with three variations namely regular, hole filled and border. The sample templates for three font styles with three variations are shown in Fig. 4. Binary image templates are converted into vectors of size 1008×1. These binary vectors are used to train the ANN. In testing phase, the input vehicle image is passed through the steps mentioned in section III, as shown in Fig. 5.

Experimentally finalized values of parameters of ANN used to achieve maximum recognition accuracy are shown in TABLE II. Experimental results for the proposed MSLPR system evaluated over a small size private database are shown in TABLE I.

There is no standard database available for experimentation.

TABLE I: Experimental results for the proposed MSLPR system

LPR Steps	Image Count	Accuracy(in %)
LP Localization	92/100	92
Character Segmentation	92/100	92
Character Recognition	87/100	87

TABLE II: Experimentally finalized values of parameters of ANN

ANN parameters	Values
No. of neurons in input layer	1008
Transfer function for input layer	linear
No. of neurons in hidden layer	336
Transfer function for hidden layer	tansig
No. of neurons in output layer	36
Transfer function for output layer	softmax
Training function	trainscg
Performance function	crossentropy
Maximum epochs	10000
Performance (minimum crossentropy)	0
Maximum validation failures	6
Termination Condition	Minimum crossentropy or maximum epochs or validation stop
Initial weights and bias	Randomly generated values between [0 1]
Number of Hidden layers	1

Researchers have developed their own private database by collecting the vehicle images near by their geographic locations. Different countries follow different formats for LPs. Hence, it becomes difficult to train and test the newly developed LPR systems with the vehicle images from internet. Moreover, it becomes difficult to compare the results of newly developed LPR systems with the results proposed by the researchers from different countries. In such cases, the methods proposed by other researchers are trained and tested over the private database and then the results are compared with the newly proposed method evaluated on the same private database.

The proposed MSLPR system is evaluated over 100 Indian vehicle images as compared to the LPR system proposed by Karthikeyan and Vinothkumar [18] evaluated over 12 Indian vehicle images. The results proposed by Karthikeyan and Vinothkumar [18] are greatly improved by using better morphological operations for character segmentation and ANN instead of template matching for character recognition, in the proposed MSLPR system, as shown in TABLE I.

V. Conclusion

A novel method for multi-style license plate recognition using morphological operations and Artificial Neural Network for Indian vehicles is proposed in this paper. License plate localization, character segmentation and character recognition accuracy of 92%, 92% and 87% is achieved using the proposed system, respectively. Total accuracy of 89.5% is achieved using the proposed system. The proposed system is trained and tested for three font styles namely, Arial, Courier and Times New Roman. The proposed system is tested over a private small size database. In future, the system can be trained for more number of font styles and tested on a large Indian vehicle database.

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