Automatic Reading of Vehicle Numbers from Number Plate

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ABSTRACT
Automatic reading of number plate in vehicles is a character recognition system, which detects the characters from the segmented number plate of the vehicle image. The work presented in this paper is to segment the characters initially from the number plate followed by recognition of the segmented characters. The skew corrected and noise free number plate image is initially segmented into its constituent parts to obtain the characters individually through projection profile technique. Later the segmented individual characters are subjected to recognition using template matching technique. Experimentation is carried out to find the recognition efficiency from the segmented number plate of the vehicle image obtained under different environment conditions.

Keywords
Number plate, Segmentation, Projection profile, Recognition, Template matching

1. INTRODUCTION
Vehicle Number Plate Recognition system is an application of image processing, developed to track the information about vehicles through the number plates. This application is gaining popularity in security and traffic monitoring systems. The number plate recognition system is important for variety of applications like automatic traffic congestion charge system, access control, tracing of stolen cars and identification of traffic rules violations. The number plate recognition plays a major role in automatic monitoring of traffic rules and maintains law enforcement on public roads. The use of vehicles is increasing in recent years because of population growth and human needs. Monitoring legal use of vehicle has become difficult and posing severe problems. Hence, an efficient monitoring system is required to ease out such situations. In this direction automatic number plate identification systems assist concerned authorities in their routine tasks.

Number plate reading is the recognition of characters in the number plate of vehicles. Recognition is the prime requirement in automatic text reading and is a two-stage process: first stage is feature extraction [1] and the second one is classification [2]. Feature extraction involves collection of useful data from given samples. Classification is the categorization of the sample through defining discriminate functions based on the extracted features. Conventional pattern classification [3] is based upon two approaches: non-numeric and numeric methods. The non-numeric approach involves fuzzy theory [4] or knowledgebase [5] for inference, while the numeric approach involves deterministic or statistical methods for inference.

The work presented in this paper focuses on implementation of automatic reading of vehicle number plates which are assumed to be segmented from the vehicle image and are skew corrected. The rest of the paper is organized as follows section 2 gives brief survey about related research work. Section 3 presents the model designed for reading of number plate. Section 4 discuss is about the experimental results and a brief conclusion is provided in section 5.

2. LITERATURE SURVEY
Two major phases involved in the number plate reading are character segmentation and character recognition. Good numberof research works are reported in literature on segmentation of characters in the number plates.

The work in [6] proposed a novel adaptive approach for character segmentation and feature vector extraction from considerably degraded images. The algorithm is computationally more complex and cannot be extended for real time number plate recognition. The work proposed in [7] is based on single frame approach using Markov Random Fields which simultaneously utilizes spatial and temporal information. The segmentation results were more suitable for automatic character recognition. The brightness distribution of various positions in a number plate image may vary with condition of the number plate and the effect of lighting environment. The binarization with one global threshold cannot always produce useful results and in such cases, adaptive local binarization methods are used [8, 9]. In our work, a simple projection profile technique [10] is adopted for character segmentation.

Similarly, considerable research works are reported on character recognition for both printed as well as handwritten text. The majority of the character recognitions are developed using any one of the approaches: 7-segment display [11], Hidden Markov Models [12, 13], Neural Networks [14-19], Hausdorff distance [20], Support Vector Machine (SVM) [21]. Each reported approach has its own advantages and limitations. Since characters in number plates are machine or hand printed not much complex recognition system is required. In this work, we have made use of a basic template matching [22] recognition technique. The design of automatic number plate reading implemented in this work is discussed in the next section.

3. PROPOSED MODEL
Input to the system is the segmented number plate from the vehicle image and assumed to be skew corrected. The output of the system is the recognized character string in the number plate. The sequence of stages in the work is shown in Figure. 1.

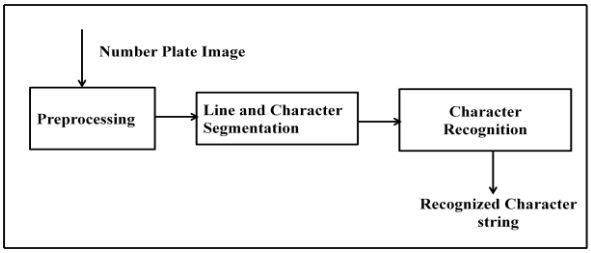
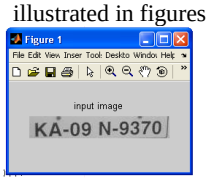


Fig.1: Flow diagram of the stages in the work

The process begins with necessary preprocessing to enhance the input number plate image for better segmentation and recognition. The preprocessed image is then considered for the line and character segmentations. The segmented individual characters are then subjected for recognition. Finally the recognized characters are concatenated to obtain the output character string. The subsequent subsection discusses both the stages in detail.

3.1 Preprocessing

Preprocessing is necessary to enhance the input image for better processing. The initial preprocessing is noise removal in the input image. The unwanted information in the background as well as foreground of the image are the noise and such noise leads to undesired results in the segmentation and recognition phases. Hence suitable noise removal methods are applied to the image before moving to next phases. In this work, binarization [23] and thresholding technique [24] are employed to remove the majority of the noise in the input image. The input image, binarized image, noise removed image and border eliminated images are illustrated in figures 3.1a through 3.1d respectively.



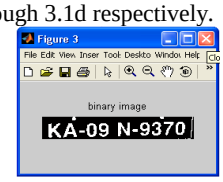
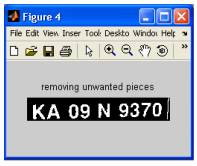


Fig. 3.1a Segmented Number plate image **Fig 3.1b Binarized**



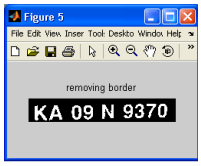


Fig.3.1c Noise Removed Image **Fig 3.1d Border removed**

3.2 Line and Character Segmentation

Number plates may have one or more lines of text. Hence it is required to segment lines first and then the characters in a line next. Segmentation of lines are done using horizontal projection and segmentation of characters in a line is done using vertical projection.

3.2.1 Line Segmentation

Line segmentation is required for the number plates having multiline text. The segmentation of plates that contain two or more rows of characters is performed using horizontal projection. Horizontal projection is the projection graph of pixels in horizontal direction. Begin and end of each line is identified by local minima from the projection graph. The local minimais reached through a valley in a graph that extends beyond a specific threshold as given in equation (1).

$$f_T(L_T) = \begin{cases} 1 & f_T(L_T) \geq T \\ 0 & f_T(L_T) < T \end{cases} \quad (1)$$

Where fT(1,i) is the vertical projection after mathematical morphology, T is the threshold. Then scan the function of fT(1, i) and register the positions where values change from 0 to 1 and from 1 to 0 in stack1 and stack2 respectively. So the candidate position of the left and right edge of the number plate are in stack1 (1,i) and stack2 (1,i) respectively. The candidate's width of the number plate is calculated as in equation (2)

$$\text{width}(1, i) = \text{stack2}(1, i) - \text{stack1}(1, i) \quad (2)$$

Figure 3.2a and 3.2b shows the graph with line segmentation from a two row number plate.

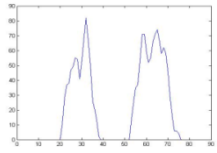
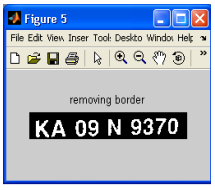


Fig.3.2a.Two rows input image **Fig.3.2b. Horizontal Projection graph**

Figure 3.2c and 3.2d shows the horizontal projection graph for a single line number plate.



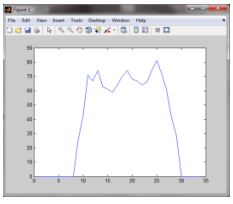
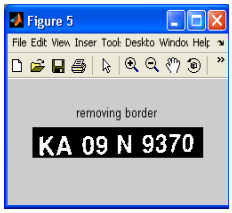


Fig 3.2c. Noise free image **Fig. 3.2d Horizontal Projection**

3.2.2 Character Segmentation

Character segmentation within a line is carried out similarly using vertical projection. For vertical segmentation each segmented character follows the same procedure as in the horizontal projection to get the vertical bounds is shown in Figure 3.2e and 3.2f.



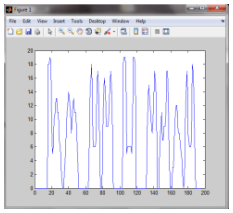


Fig. 3.2e. Noise free image **Fig. 3.2f. Vertical Projection**

3.3 Character Recognition

Any character recognition algorithm has two essential components feature extractor and classifier. Feature analysis determines the descriptors or the feature set used to describe all characters. Given a character image, the feature extractor derives the features that the character possesses. The derived features are then used as input to the character classifier [25]. Template matching or matrix matching, is one of the most

common classification methods, which is being used in this work.

Template is basically a defined pattern [26]. In Image processing, template matching techniques are used to compare portions of images against one another and individual image pixels are used as features. Classification is performed by comparing an input character with a set of templates from a character class [27]. Character classification using template matching initially require, the input character image to be normalized [28] to the size 15x15 of the template. The normalized image is subjected for recognition through template matching. A measure of similarity is performed between the input character with a set of templates. The measure of similarity increases when a pixel in the input character is identical to the same pixel in the template image and the measure of similarity decreases otherwise. After all templates have been compared with the observed character image, the character's identity is assigned the identity of the most similar template. Similarity measure is done on a pixel-by-pixel basis using 2-D normalization correlation [29] as given in equation (3).

$$R(I,Tn) = \frac{\sum_{i=0}^{w}\sum_{k=0}^{n}(\mathrm{I(i,j)}-|\mathrm{I}|)(\mathrm{T(i,j)}-|\mathrm{T}|)}{\sqrt{\sum_{i=0}^{w}\sum_{k=0}^{n}(\mathrm{I(i,j)}-|\mathrm{I}|)^2 (T(i,j)-|T|)^2}} \qquad (3)$$

The input character under consideration is compared with each template to measure similarity. If I(x, y) is the input character, T(x, y) is the template n, then the matching function R(I,T) will return a value indicating how well template n matches the input character.

Using Equation (3) calculate the matching score of segmented character. The match score is generated for each character in the image is matched with all the score in the template database. The nearest score matching is considered to be the recognized character string. Finally the recognized characters are concatenated to form the recognized character string.

4. EXPERIMENTAL RESULTS

The designed method is implemented on MATLAB 2009a. A good number of number plates images are considered for experimentation containing single line and multi lines. For the comprehension and the input image, segmentation and recognition is shown in figures 4a, 4b and 4c respectively.

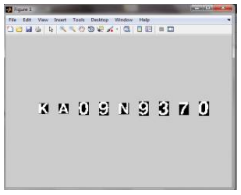


Fig. 4a. Input Image **Fig.4b. Character Segmentation**

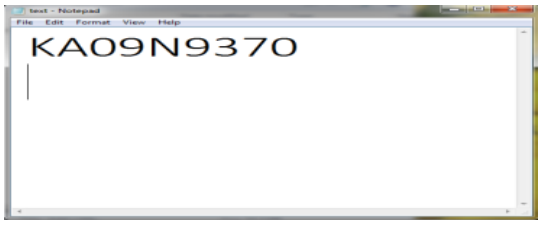


Fig.4c. Recognized Character String

The experiments are conducted on 273 detected vehicle number plate images. The vehicle number plate images are taken under different environment conditions with single line and multi line vehicle number plate. The experiment is conducted in two phases: segmentation and recognition. In first phase, correct segmentation of 64% for single line and 44% for multi line vehicle number plate is noticed and also incorrect segmentation of 34% for single line and 56% for multi line characters is observed. The conducted experimental results for segmentation on both single line and multi line are shown in Table. 1.

In second phase, recognition is done for segmented characters from vehicle number plate. In this phase recognition rate is considered on single line and multi line vehicle number plate. The correct recognition rate is observed 42% and 37% for single line and multi line vehicle number plate and incorrect recognition rate is 58 % and 63% for single line and multi line vehicle number plate respectively. Table 2. shows the results of character recognition on both correctly segmented number plates

Table.1 Results of Character Segmentation

Input form	No. of Number plate	No.of Correct Segmentation	No.of Incorrect Segmentation	Percentage of Correct Segmentation	Percentageof Incorrect Segmentation
Single Line	176	113	63	64	36
Multi Line	97	43	54	44	56

Table. 2 Results of Character Recognition

Input form	No. of Correct Segmented	No. of Correct Recognition	No. of Incorrect Recognition	Percentage of Correct Recognition	Percentage. of Incorrect Recognition
Single Line	113	48	66	42	58
Multi Line	43	16	27	37	63

5. CONCLUSION

A simple and effective template matching method implemented for vehicle number plate recognition system. The method use projection techniques for line and character segmentation. The recognition of characters are made through template matching technique. The segmentation shows an average result of 57% and recognition results is around 41%. The attempt is only to understand the issues in number plate

reading and the method cannot be extended for generic applications, as more complex issues are involved in real time applications The segmentation do not work for connected characters, artistic characters and inverted number plates. In addition, template matching is a very slow and cannot be employed for real time applications.

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