An Improved Intelligent Transportation System: An Approach for Bilingual License Plate Recognition

Nikita Singh and Tarun Kumar

Abstract An intelligent transportation system (ITS) is the leading-edge technology that is used to control the traffic and prevent the rule violators. The ITS systems are equipped with an automatic number plate recognition (ANPR) techniques which recognize the license plate of the vehicles. This paper proposes an approach for Hindi license plate recognition and extends the ability of ITS systems. In the proposed approach, connected component labeling is used for character segmentation and histograms of oriented gradient (HOG) features are used to classify the Hindi characters. We propose an integrated classification model for character classification. To classify the alphabets and numerals, a ANN model is designed and trained for datasets. The approach segments the characters with 100% accuracy, and average accuracy of the classification model is 96.7%.

Keywords Character segmentation · Character recognition · HOG · ANN

1 Introduction

At Present, security overrides every other aspects of our society and it is prime issue for our nation. It ensures the integrity of the society and hence its prosperity. Surveillance is the most significant part of this security system. Many different facets exist for this surveillance system. At the highest level of abstraction, it can be either manual or automated. The automated surveillance system involves image processing techniques. Manual surveillance is tedious, time-consuming, error-prone involving

N. Singh (✉)
Department of Computer Science and Engineering,
Banasthali University, Banasthali, Jaipur, India
e-mail: nikitasinghk@gmail.com

T. Kumar
Department of Computer Science and Engineering,
Government Engineering College Bikaner, Bikaner, India
e-mail: ertarun123@gmail.com

S. C. Satapathy and A. Joshi (eds.), *Information and Communication Technology for Intelligent Systems*, Smart Innovation, Systems and Technologies 107,
https://doi.org/10.1007/978-981-13-1747-7_4

huge financial burden. Surveillance based on image processing techniques generally involves a camera, and the streaming video may be monitored in real time or may be later processed for other monitoring activities. When it comes to tracking and locating any suspicious vehicle either within the city limits or outside, automatic number plate recognition (ANPR) system plays a major role.

The existing ANPR systems are more accurate and efficient but still face some issues related to recognition of language-specific license plates. In countries such as India, the license plate style varies from region to region. In north India, license plates embedded with Devanagari letters are widely used along with English letters. Hindi character recognition is a challenging task due to the variance of its characters. The Hindi language comprises 10 vowel characters and 42 base consonants, and each base consonant has 12 individual forms. Existing ANPR approaches are compatible with English language. The ANPR systems for Hindi license plates must be able to recognize variety of the characters. Many researchers use deep convolution neural network (DCNN) for recognition of Hindi characters, but approaches are not computationally efficient and require specific hardware such as GPU. Most ANPR systems work in real time and have limited computing resources. This paper proposes an computationally efficient approach for Hindi license plate recognition based on artificial neural network (ANN). The approach can also detect multiline license plates.

2 Related Work

A license plate detection technique detects the license plates from the image of the vehicle. Detected license plate is then processed by the character segmentation approach. Character recognition techniques recognize the individual characters. This paper proposes an approach for character segmentation and character recognition. There exist various techniques for character segmentation based on blob region analysis, histogram intensity projection, connected component labeling, etc. Cheng et al. [1] propose pixel connectivity-based character segmentation approach, where eight-neighbor pixel technique is used to label the characters. The aspect ratio of the license plate is used to verify the labeled characters. Wang et al. [2] use projection profiles of characters in binary image of license plate. Characters are segmented based on geometrical parameters such as height and width. Capar and Gokmen [3] propose a fast marching algorithm to extracts the contours of the characters. These character recognition approaches are based on prior knowledge of the characteristics of the character to be recognized, i.e., English characters, Chinese characters. The template matching, optical character recognition (OCR), and ANN are the popular approaches for character recognition. Template matching method [4–7] is used to identify the segmented character by matching with the template. Identification is performed by calculating the correlation coefficient. The highest correlation coefficient is identified as the character. In template matching, the matrix containing the image of the input character is directly matched with a set of template characters. Stentiford et al.

[8] propose an approach for OCR based on feature detection. In this approach, the characters recognition is based on the key features of the characters including height, width, density, and loops. Patil et al. [9] also use neural network in optical character recognition. Ahmed et al. [10] report that an OCR technique based on fuzzy logic achieves good results, but it requires complex computations. ANNs [4, 11] are trainable algorithms that can 'learn' to solve complex problems from training data that consist of a set of inputs and desired outputs. These can be trained to perform a specific task such as prediction and classification. Glorot and Bengio [12] discuss the difficulty of training deep feed-forward neural networks.

In India, various vehicles use multiline and multilingual license plates. The characters segmentation approaches must be able to segment multiline license plate characters. This paper proposes an approach for multiline character segmentation and Hindi character recognition. These approaches are integrated to recognize the Hindi license plates.

3 Proposed Work

The objective of the proposed approach is to increase the capability of the existing ANPR system by providing multiline character segmentation and Hindi character recognition. The approach proposed in this paper has two main modules. The first module is for multiline character segmentation, and another one is for character recognition. Figure 1 shows the workflow of the proposed approach.

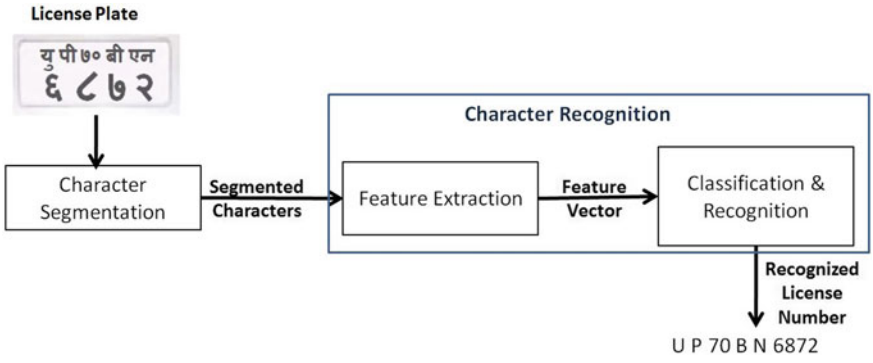

Fig. 1 Workflow of the proposed approach

3.1 Character Segmentation

This proposed module segments the characters in license plates and preserves the order of appearance of each character. In multiline license plates, the license numbers are written in more than one line. This characteristic of the license plates requires that after the segmentation, characters must be recognized in the same order in which they appear in license plates. The approach is based on segmentation of lines using horizontal intensity histogram projection [13]. To obtain the projection profile, license plate is converted into binary image. In binary image of license plate, background pixels have value '1' and foreground pixels have value '0', so the image inverted. The projection profile segments the individual lines. To preserve the order of the lines, labeling of each line is carried out from top to bottom in projection profile. During labeling, each line associates with a sequence number that is assigned in order. Each segmented and labeled line is stored in vector. Figure 2 shows an example of the line segmentation.

In Fig. 2, L_1, L_2, and L_3 are the sequencing of the segmented lines. These segmented lines are used in character segmentation process. In Hindi character segmentation, the main challenge is to deal with the character styles. In Hindi, the characters are joined by a line and some Hindi letters are composed of base consonants and sign. These different signs may appear on head of the consonants or in bottom strip, i.e., Line L_2 in Fig. 2a. This formation of Hindi letters is difficult to isolate the characters. In the above line segmentation approach, the letters with top strips of singed are isolated easily, but the letters with bottom sign are isolated in different lines. This is because, the sign at the top of the consonant generally forms connected component, whereas the sign at bottom does not. In first phase of character segmentation, the characters from each lines are segmented and in second phase, the consonants with corresponding signs are joined together. To segment the characters, connected component analysis (CCA) [14] is used from left to right direction. This isolates the characters in each line, and each isolated character is labeled with sequence number. This sequence number is composed of line number and the order number as shown in Fig. 2b. The consonants and signs are joined together by comparing the horizontal coordinates of the character regions.

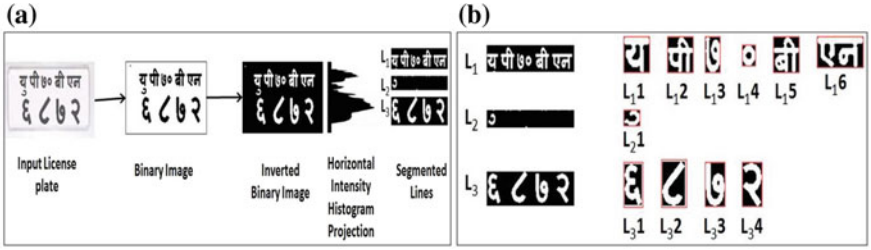

Fig. 2 **a** Workflow of the proposed line segmentation. **b** Illustration of character segmentation and labeling

In each line, the position coordinates of each character are stored with the labeled characters images.

Let L_1, L_2, L_3, etc., represent the segmented lines in license plates. The segmented characters in L_1 are labeled, and the position of each character is stored in vector R that contains x- and y-coordinates of top left point of the contour rectangle and width and height.

$$C_{L1} = \{(R, L_1 1), (R, L_1 2), (R, L_1 3) \ldots (R, L_1 n)\};$$
$$\textit{And so in } L_2 \textit{ and } L_3$$
$$C_{L2} = \{(R, L_2 1), (R, L_2 2), (R, L_2 3) \ldots (R, L_2 n)\};$$
$$C_{L3} = \{(R, L_3 1), (R, L_3 2), (R, L_3 3) \ldots (R, L_3 n)\};$$
$$R = \{x, y, w, h\}$$

So the vector C_{Ln} stores each labeled character image with corresponding vector R. The algorithm for segmentation is proposed here.

Algorithm: Segmentation

```
Input: Image of license plate, I
Output: Segmented character vector Sc
Procedure Segmentation (Image I)
{ Ig = rgb_to_grey(I); th= greythresh(Ig);
  Ib= grey_binary(Ig, th); Horizontal_profile= Histh(Ib);
  peak =find_peak(Horizontal_profile);
  min = find_min(Horizontal_profile);
  k=0; for (i=0;i< m;i++){
      If Horizontal_profile[i]<peak && Horizontal_profile[i] > min
         Lk=I; k++;
          For (k=0;k < Lk.length; k++){
          CLk = labeled_CCA(region_props(left_to right), Lk )}
             For (k=0;k < CLk.length; k++){
             For (j=0; < CLk.length; j++){
               If( CLK ->(R.x+R.w) < = CLj ->(R.x+R.w)}
                   Join(CLK, CLj );}
           Sc.add(CLk); Return Sc;}
```

Algorithm returns a vector S_c that contains the image of the labeled image isolated characters.

3.2 Character Recognition

The character recognition approach is based on the ANN. The texture features of the characters are used in training of the ANN. This module is comprised of two independent sub-modules, namely feature extraction and classification and recognition. Feature extraction module extracts the texture features using histogram of

oriented gradients (HOG) [15]. These extracted features of the characters are combined together to train the neural network.

3.2.1 Feature Extraction

The characters in the Hindi language have curvy shapes. The locality of the curve in the shapes varies from character to characters. In this proposed approach, characters are classified based on the locality of curvy features. To detect the curvy features in each image, the image is subdivided horizontally into four cells and vertically into two cells. The HOG features of all the six cells are combined together to obtain the feature vector. Prior to feature extraction, each image of isolated characters is resized to 80×40 pixels. The horizontal cell division is carried out by dividing the image into four cells of 20×40 pixel size from top to bottom direction. In vertical cell division, image is divided into two 80×20 pixel cells from left to right direction. Figure 3 shows image division of the approach (Fig. 4).

The HOG feature extraction is performed for all the cells, and a feature vector composes all the features. The feature vector can be defined as:

```
F = {HOG (cell1), HOG (cell2), HOG (cell3), HOG (cell4), HOG (cell5), HOG (cell6)}
```

3.2.2 Classification and Recognition

This classification module classifies the images of characters into predefined classes. A feed-forward ANN is used for classification of Hindi alphabets and Hindi numerals. The neural network is trained with gradient descent back-propagation algorithm [16].

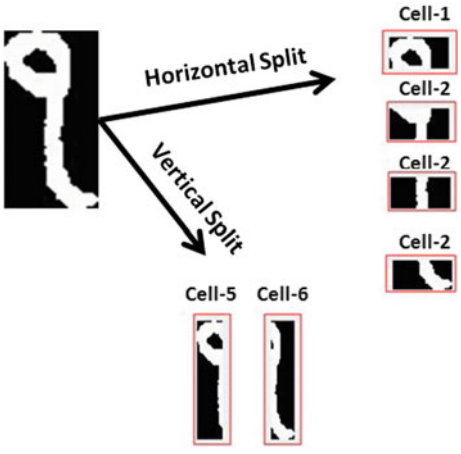

Fig. 3 Image subdivision into cells for feature extraction

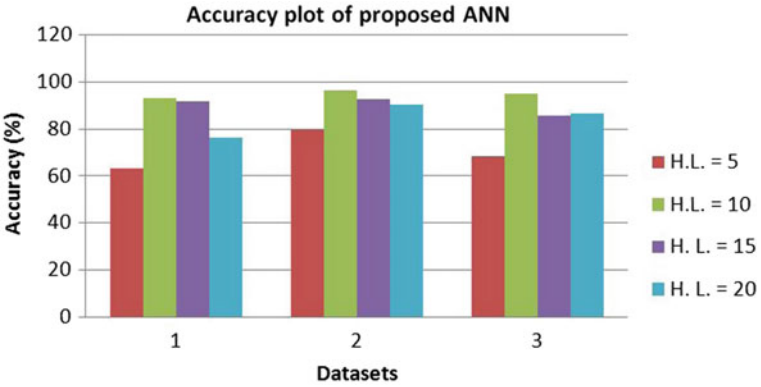

Fig. 4 Average accuracy of the alphabet classifier in different training datasets and different numbers of hidden layers

Table 1 Accuracy of the approach on license plate dataset

S. no.	Segmentation	Multiline LP (line segmentation)		Single-line LP (line segmentation)		Character segmentation
		Number	Accuracy (%)	Number	Accuracy (%)	Accuracy (%)
1	Correct	62	95.4	35	100	100
2	Incorrect	3	4.96	0	0	0
	Total	65	100	35	100	100

In the training of the ANN, the HOG feature vector is used. The HOG feature-based classification improves the accuracy of character recognition.

4 Result and Analysis

The existing methods are capable of the segmentation of the license plate characters that are situated in a single line. The character segmentation algorithm and character classification modules are implemented in MATLAB. To verify the character segmentation approach, we generate a dataset which contains 100 license plates consisting of multiline and single lines. In these license plates, the license numbers are written in Hindi languages. The algorithm is tested on dataset of Hindi license plates. The performance analysis of the algorithm and parameters such as accuracy in line segmentation and accuracy in character segmentation are recorded (Table 1).

The average accuracy of the proposed segmentation approach is 97.7% for line segmentation and 100% for character segmentation. For the classification and recognition of these isolated characters, ANN is used. The two datasets of Hindi characters

of 10 different styles are used. The first dataset contains total of 556 sample characters including 10 vowels characters, 42 consents characters, and 12 forms of each consonant character written in 10 different styles, and the second dataset contains total 100 characters including all 10 numeral characters written in 10 different styles. The size of each character in both datasets is 80×40 pixels.

4.1 Training of ANN

The neural network is trained to classify the class of each character in alphabets. Three datasets are used in the training of the neural network. In the pre-training phase, a feature vector which contains HOG features of all characters in alphabets class is obtained. In the target class vector, totally 556 classes are defined: 10 classes for vowels, 42 classes for base consonants, and remaining 504 classes for 12 different forms of each base consonant. The target vector of numeral characters that contains ten different classes is designed for 0–9 characters. The accuracy of the neural network of different sizes is recorded to obtain stable ANN. A stable and accurate model is obtained by training the network on three datasets with different numbers of hidden layers. Table 2 shows the accuracy of the ANN in different training sessions.

The above results reveal that the ANN with ten hidden layers on the second dataset achieves average accuracy of 96.7%. We use this model in the approach for alphabet character classifications. This neural network achieves the average accuracy of 96.7%. We adopt this model in the final classification model. Character recognition that is based on the class of the characters extracts the corresponding recognized characters. The mapping of defined character class and corresponding English character is used for character recognition.

5 Conclusions

This paper proposes a novel approach for Hindi license plate recognition. The approach includes character segmentation and character recognition of Hindi license plates. To classify the license plate characters, ANN is used. The proposed segmentation algorithm is efficient for multiline license plate as well in single-line license plate. The average accuracy achieved for segmentation is 98.5%. The average accuracy of both classifiers (alphabet classifier ANN and numeral classifier ANN) is above 96.7%. The proposed approach is based on ANN, and hence, it is efficient with limited computation resources. The integration of the proposed approach in existing ANPR systems will improve the capability of ANPR and hence the intelligent transportation system.

Table 2 Accuracy of the alphabets classifiers in different training sessions

S. no.	H. l.	Training			Validation			Testing		
		Samples (alpha.)	Samples (num.)	Accuracy	Samples (alpha.)	Samples (num.)	Accuracy	Samples (alpha.)	Samples (num.)	Accuracy
1	5	390	28	82.7	83	6	53.8	83	6	53.2
		778	56	84.4	167	12	70.6	167	12	83.5
		1946	70	83.9	417	15	71.6	417	15	49.4
2	10	390	28	97	83	6	93.5	83	6	89.4
		778	56	98.3	167	12	96.5	167	12	95.7
		1946	70	93.5	417	15	91.5	417	15	100
3	15	390	28	88.6	83	6	87.2	83	6	99.1
		778	56	92.3	167	12	86.7	167	12	99.5
		1946	70	86.8	417	15	88.3	417	15	82.7
4	20	390	28	71.5	83	6	78.1	93	6	80.8
		778	56	76.6	167	12	99.3	93	12	95.2
		1946	70	73.1	417	15	94.8	93	15	91.5

References

1. Chang, S.L., Chen, L.S., Chung, Y.C., Chen, S.W.: Automatic license plate recognition. IEEE Trans. Intell. Transp. Syst. **5**(1), 42–53 (2004)
2. Wang, T.H., Ni, F.C., Li, K.T., Chen, Y.P.: Robust license plate recognition based on dynamic projection warping. In: 2004 IEEE International Conference on Networking, Sensing and Control, vol. 2, pp. 784–788. IEEE (2004)
3. Capar, A., Gokmen, M.: Concurrent segmentation and recognition with shape-driven fast marching methods. In: 18th International Conference on Pattern Recognition, 2006. ICPR 2006, vol. 1, pp. 155–158. IEEE (2006)
4. Ibrahim, N.K., Kasmuri, E., Jalil, N.A., Norasikin, M.A., Salam, S., Nawawi, M.R.M.: License plate recognition (LPR): a review with experiments for Malaysia case study. arXiv:1401.5559 (2014)
5. Vishwanath, N., Somasundaram, S., Nishad, A., Nallaperumal, N.K.: Indian license plate character recognition using Kohonen neural network. In: 2012 IEEE International Conference on Computational Intelligence & Computing Research (ICCIC), pp. 1–4. IEEE (2012)
6. Ashtari, A.H., Nordin, M.J., Fathy, M.: An Iranian license plate recognition system based on color features. IEEE Trans. Intell. Transp. Syst. **15**(4), 1690–1705 (2014)
7. Kumar, T., Gupta, S., Kushwaha, D.S.: An efficient approach for automatic number plate recognition for low resolution images. In: Proceedings of the Fifth International Conference on Network, Communication and Computing (ICNCC 2016), pp. 53–57. ACM (2016)
8. Stentiford, F.W.: Automatic feature design for optical character recognition using an evolutionary search procedure. IEEE Trans. Pattern Anal. Mach. Intell. **3**, 349–355 (1985)
9. Patil, V., Sanap R.V., Kharate, R.B.: Optical character recognition using artificial neural network. Int. J. Eng. Res. Gen. Sci. **3**(1) (2015)
10. Ahmad, S., Boufama B., Habashi, P., Anderson, W., Elamsy, T.: Automatic license plate recognition: a comparative study. In: 2015 IEEE International Symposium on Signal Processing and Information Technology (ISSPIT), pp. 635–640 (2015)
11. Rabee, A., Barhumi, I.: License plate detection and recognition in complex scenes using mathematical morphology and support vector machines. In: 2014 International Conference on Systems, Signals and Image Processing (IWSSIP), pp. 59–62. IEEE (2014)
12. Glorot, X., Bengio, Y.: Understanding the difficulty of training deep feedforward neural networks. In: Proceedings of the Thirteenth International Conference on Artificial Intelligence and Statistics, pp. 249–256 (2010)
13. Iamsa-at, S., Horata, P.: Handwritten character recognition using histograms of oriented gradient features in deep learning of artificial neural network. In: IEEE International Conference on IT Convergence and Security (ICITCS), pp. 1–5 (2013)
14. Suzuki, K., Horiba, I., Sugie, N.: Linear-time connected-component labeling based on sequential local operations. Comput. Vis. Image Underst. **89**(1), 1–23 (2003)
15. Dalal, N., Triggs, B.: Histograms of oriented gradients for human detection. In: IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), vol. 1, pp. 886–893 (2005)
16. Mandic, D.P.: A generalized normalized gradient descent algorithm. IEEE Signal Process. Lett. **11**(2), 115–118 (2004)