A Hybrid Machine Learning based Approach for Hindi License Plate Recognition

Nikita Singh, Tarun Kumar and Sharbani Mallick

Abstract*: In the present era of revolutionary techniques, the developed countries are using various technologies to provide the better quality of social life. In these technologies the automatic number plate recognition is playing vital role in intelligent transportation management. Most state-of-the-art ANPR are compatible with language specific license plates specifically English. The langue-specific characteristics limit the competence of ANPR where more than one language is used in license plates. In this paper a system for recognition of Hindi license plates is proposed. The proposed approach is based on hybrid machine learning techniques such as support vector machine and artificial neural network. These two different machine learning approachs are integrated in order to improve the performance of system. The average license plate recognition accuracy of proposed approach is above 96% in recognition of Hindi license plates.

Index Terms*: Character Segmentation, Character Recognition, HOG, SVM, ANN.

I. INTRODUCTION

In the development of the smart cities the various technologies are being used to provide the smart infrastructure. In the smart cities, the better west management, smart transportation management, smart power grid etc. system makes notable contribution. Smart transportation management is the intrinsic need of the nation as the population is increasing in the cities as results the traffic problems such as jams, accidents, and rule violations are also increasing. Smart transportation and monitoring system is the only solution to deal with such traffic problems. In the smart transportation system, automatic speed detection of the vehicles, detection of the traffic rule violation, detection of traffic congestion and management of traffic lights are major task that are need to be include. Automatic number plate recognition (ANPR) system is the backbone of the all task of smart transportation management system. ANPR system recognizes the license number of the vehicle from the image of that vehicle. This requires efficient image processing techniques and machine learning ability to recognition the license plate. Recognition of license plates is a challenging because of the veracity in license plate style. At present, the authorities create a rule for license plate number and style but these rule does not limit the font style, language style and size of the fonts. Due this limitation, there wide varieties of the license plate do existing in different states. In India, after the English, license plate number written in Hindi is popular. Hence, the system that can recognize the Hindi license plate is also required for smart transportation management.

Recognition of Hindi character not an easy task due the different texture structure of each character and existence various writing styles. However, among the various writing styles Devanagri script is popular and used in the majority of Hindi license plates. This paper proposes an approach for recognition of the Hindi license plates written in Devanagri script. In the approach, an integrated machine learning module containing a support vector machine and two different artificial neural networks is designed. The approach proposed in this paper can be integrated to the existing ANPR system that recognizes the English license plates. Overall, the proposed system will extend domain of exiting ANPR system.

Revised Manuscript Received on May 28, 2019.

Nikita Singh,CSED, Banasthali University, Banasthali, Jaipur, India nikitasinghk@gmail.com.

Tarun Kumar, CSED, MNNIT Allahabad, Prayagraj, India, ertarun123@gmail.com

Sharbani Mallick, CSED, Dr. B.R Ambedkar Institute of Technology Port Blair, India , shrabani.reek@gmail.com

II. RELATED WORK

The ANPR is an image processing technique that extracts the symbols - characters or numerals from number plate and recognizes these symbols in order to identify the vehicles. This comprises of three different techniques namely; license plate detection, character segmentation and character recognition.

License plate detection system scans the image of the vehicle and finds the position of the license plate in the image. The position includes the coordinates of the license plates, width and height of the license plate. This is based on various license plate features. The detected license plate is isolated from the image of the vehicle and processed in character segmentation module. In this module, image of the each individual character needs to be segregated from license plate. This is because license plate recognition is only possible by recognition of individual characters. The isolated images of the characters are processed in character recognition module for recognition of character.

Cheng et al. [1] proposes an approach for segregation of character images from image of license plate. The approach is based on 8-pixel connectivity and aspect ratio of each character in English language. Intensity projections of characters are also used for segregation of characters in license plate as in [2]. Characters in the license plates haves different textures and shapes. Therefore the contour tracking approach is proposed in [3] from segregation of the character's images from the license plate. However this requires prior knowledge of the shape and texture properties of the different characters from different languages.

To recognize the isolated images of the characters,

template matching and Optical character readers are widely used in the past. In template matching approach, the image of the isolated characters is matched with the labeled images of characters in repository. The nearest match of the license plate character with repository characters is recognized as the label of template. The correlation coefficient is widely used for matching the characters [4-7].

In OCR, the intensity pattern of isolated character is utilized for recognition. The intensity pattern such as variation of intensity along with height, intensity density are used in [8] for OCR character recognition. Patil et al. [9] proposes a machine learning approach for recognition of character using OCR features. Ahmed et al. use fuzzy logic on OCR features in order to improve the accuracy of the system. However, the fuzzy logic based approach requires complex computations.

Machine learning algorithms are far better in recognition of the character as compared to the traditional template matching and OCR based approach. There exist wide varieties of the machine learning approaches such as support vector machine, decision tree, random forest, cascade classifier, artificial neural network (ANN) etc.

At present, research communities are adopting ANN for various artificial intelligence applications due to its learning ability and lesser effort. ANN learns to solve the complex problem by the training from feature based dataset. This ANN can be used for classification and prediction as well [4] [11]. Neurons in the ANN adjusts their weights based on the supervised learning on given dataset.

In image processing, the evolution of the convolution neural network (CNN) attracts the attention of various researchers. CNN based applications are achieving good results as compared to existing machine learning approaches. Glorot and Bengio [12] reviews pros and cons of the CNN and ANN. In this study, authors find that ANN requires more effort in training but the CNN does not requires any effort during the training. However, CNN based approach requires specific hardware support such as graphics processing units (GPU) for efficient and faster training. Apart from the technical perspective, the various vehicles have license plate written in multiple lines also. This introduces another challenge for research community to deal with. As most of the character segmentation approaches are indented to segment the single line license plates.

The above discussion is evident that the machine learning approaches are needs to be integrated in order to recognize the Hindi license plates. This paper proposes a hybrid machine learning model with integration of efficient character segmentation technique for the said objective.

III. PROPOSED WORK

This paper proposes an approach for ANPR to recognize the Hindi license plates. The objective is to cover the all that challenges such as recognition of single line and multiline license plate. The proposed approach is divided in two phases namely character segmentation and character recognition. In first phase, the detected license plate is processed in order segregate the image of each character. It is assumed that there exists a system for detection of license plate. The proposed system only processes the detected license plate. Segregated characters from license plate are the processed in character recognition phase. The flow of the approach is shown in figure 1.

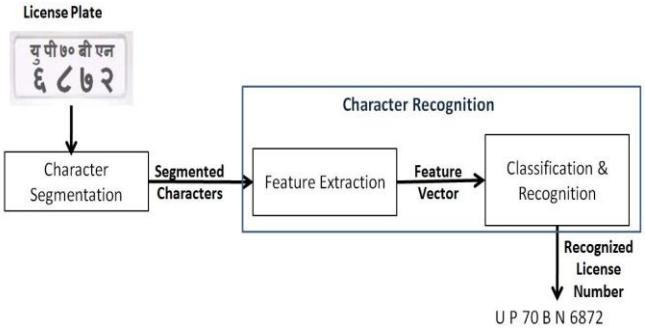

Fig.1. Flow of the Proposed Hindi ANPR

A. Character Segmentation

This phase of proposed ANPR finds the characters in license plate and segregates the image of each individual character from the license plate. This phase deals with challenges to deal with single line and multiline license plates. In single line license plate, the license numbers are written in along with single line. The segregation in single line only requires labeling the ordering of isolated characters. In multiline license plate, license numbers are written in multiple lines. Hence, it is necessary to keep the order of appearance along with the line in which is these are appear. To address these requirements, the segmentation process is completed in two phases. In first phase, the line segmentation is performed on detected license plate. This ensures the isolation of each line from the license plate. The intensity projection profile is used for detection of license plate lines. In horizontal intensity projection profile the region with higher intensity [13] are classified as the license plate lines. This technique helps to isolate the lines from the license plate. The labeling of line segmentation is also required to maintain order of appearance. The line segmentation is performed from top to bottom in license plate. Hence, the line numbers are attached to the isolated images accordingly. The line segmentation in labeling of line is also illustrated in the figure 2.

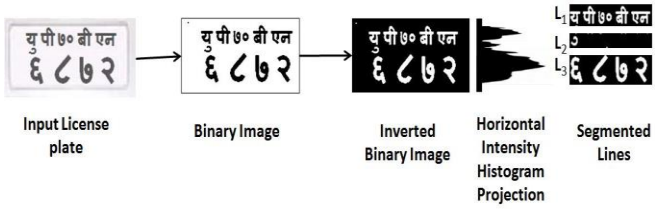

Fig. 2. Illustration of line segmentation from license plate

These segmented lines are used in character segmentation process. In Hindi language, characters written along with a horizontal line and composed of base consonants and sign. During the line segmentation these consonants and sign may be segregate into different lines. Hence, the characters segmentation needs to combine these consonants and sign to the respective character before isolation of the character image.

Next phase is character segmentation from the isolated and labeled lines of license plates. This paper use connected component analysis (CCA) [14] for character segmentation. In order to

segregate the character image, the isolated line is scanned from left to right. The labeling of the each character according to order of appearance is also done in this phase. To label the each character, the line in which it detected is also labled along with order. This labeling will helps to combine the base consonant with corresponding sign. The proposed character segmentation process is also illustrated in figure 3.

Fig. 3. Process of proposed character segregation and labeling

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

In the figure 2 and 3, the line numbers are represented by L_i, i is line number from top to bottom. The characters from each line are labeled by using line number and the position vector V. This vector stores the coordinate of the character from top left coroner height and width of character. .

$C_{L1} = \{(V,L_11),(V,L_12), (V,L_13)\ldots\ldots\ldots(V,L_1n)\};$

And so in L_2 *and* L_3

$C_{L2} = \{(V, L_21), (V, L_22),(V, L_23) \ldots\ldots(V, L_2n)\};$

$C_{L3} = \{(V, L_31), (V, L_32),(V, L_33)\ldots\ldots\ldots(V,L_3n)\};$

$V = \{x, y, w, h\}$

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

Algorithm: Segmentation

```
Input: Image of license plate, N
Output: Isolated character vector Sc
Procedure Char_Segmentation (Image I)
{
 Ng = rgb-to-grey(N);
 th= thresh(Ng);
 Nb= grey-to-binary(Ng, th);
 Hz_profile= His_th(Nb);
 peak = peak(Hz_profile);
 min = fmin(Hz_profile);
 k=0;
 for (i=0;i< m;i++)
   If Hz_profile[i]< peak && Hz_profile[i] > min
      Lk=i

   k++;
   For (k=0;k < Lk.length; k++)
      CLk = labeled_CCA(region_props, Lk )
      For (k=0;k < CLk.length; k++)
        For (j=0; < CLk.length; j++)
          If( CLK ->(V.x+V.w) < = CLj ->(V.x+V.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.

B. Character Recognition

Character recognition is process of mapping of isolated character images to the letter of the specific language. In this paper, a hybrid model of three different machine learning techniques is designed. At the first level, a support vector machine model is deployed to classify the isolated image of character into two categories like alphabet or numeral. As the typical license plate is compose of both alphabets and numeral. The most of existing techniques shows confusion in some alphabets and some numeral due to same texture region. Hence, the very first level filters the character images into above respective categories. In next level, there are two ANN for the above two categories. The character classified into above categories then processed by the individual ANN. The approach uses support vector machine and ANN thus the feature dataset must be require to train that model and to use that train model as well.

Characters written in Hindi language are contains rich curves, edge and gradients. Hence, Histogram of Oriented Gradients (HOG) [15] features are used to train the machine learning model.

a) Feature Extraction

Each characters in Hindi language have curve in different location such as some have curve on bottom of image, some are having curve on top side etc. So to capture these location specific features, the region based HoG features are extracted from the images. The input image of the characters in divided into six different regions after resizing into 80x40 resolutions. In these six regions, four regions are divided from top to bottom in equal partition of 20x40 resolutions. The remaining two regions are partitioned equally from left to right of 80x20 resolutions.

HoG features of these regions are extracted individually and combined in feature vector. This feature vector represents the location specific HoG features of complete image. The formulation of feature vector F is given below.

F = {HOG (region1), HOG (region 2), HOG (region 3), HOG (region 4), HOG (region 5), HOG (region 6)}

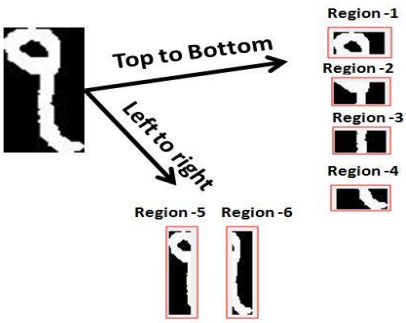

Fig. 4. Region wise feature extraction

b) Classification and Recognition

The feature vector F s used to train the machine learning model. As we discuss above, proposed machine learning module works in two levels. In first level, SVM [17] to differentiate between alphabets and numeral and in next level a feed forward neural network for both individual categories are deployed. The proposed hybrid machine learning model is shown in figure 5. The first level SVM model is trained for the both alphabet and numerals images. In next level, the individual ANN is trained for the respective categories only.

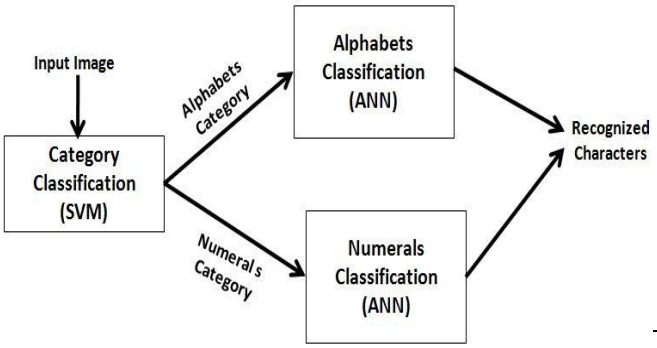

Fig. 5. Proposed hybrid machine learning model for character recognition

Both the neural networks are trained with gradient descent back propagation algorithm [16]. Category wise classification improves the accuracy of character recognition.

IV. RESULT AND ANALYSIS

In this section, the proposed approach is tested on different images and accuracy of the approach is computed for performance analysis. The approach is designed for single and multiline license plates. Hence, a dataset containing both type of license plate is used for the experiments. In the dataset there are 100 images of Hindi license plates.

Accuracy of proposed approach is recorded in two different parameters such as accuracy in correct line segmentation, and accuracy in character segmentation.

During the experiments, proposed approach achieves 97.7% accuracy in correct line segmentation from license plates. Whereas, the proposed approach achieves 100% accuracy in character segmentation.

Table 1. Accuracy of the proposed character segregation approach

S. No.	Result	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%

To train the machine learning model of the character recognition, individual dataset for alphabet and numeral is used. The alphabet dataset contains Hindi characters in ten different styles. This includes 556 sample images of characters that includes 10 vowels, 43 consents and 12 forms of each consonants. The numeral dataset contains 100 images samples of all ten (0-9) numeral written in 10 different styles.

A. Training Results of SVM Classifier

The support vector machine based on linear kernel function is used for classification of the characters image into two classes namely: alphabets class and numeral class. To train the SVM, four training datasets are designed. The first training set contains 556 alphabets (one sample of each) and 10 digits (4 sample of each). During training, feature vector includes HOG features of all characters and size of feature vector is 558 X 1224. In the second training set, the numbers of samples are increased for both the categories. In alphabets category, 1112 samples (two sample of each characters are selected and in numeral category (8 samples are selected). Third training set includes 5 samples of each character in alphabets category and 10 samples of numeral category and fourth training set includes 7 samples of each character in alphabets and 12 samples of each characters of numeral category. Accuracy of the linear SVM corresponding to all three training datasets is given in table 2. To obtain the stable model, SVM is trained for different kernel size.

Table 2. Performance of SVM during different Training sessions with different kernel (K) size

S. No.	Set	No. of Samples		Accuracy			Time in Sec.
		Alphabets	Numerals	K=1	K=3	K=5	
1	1	556	40	0.78	0.79	0.79	7.103
2	2	1112	80	0.89	0.83	0.92	9.005
3	3	2780	100	0.96	0.99	0.97	10.042
4	4	3892	120	0.93	0.90	0.94	12.006

During the training, accuracy of the SVM model is the highest at (k=3) in training set third. We adopt this model for the proposed approach.

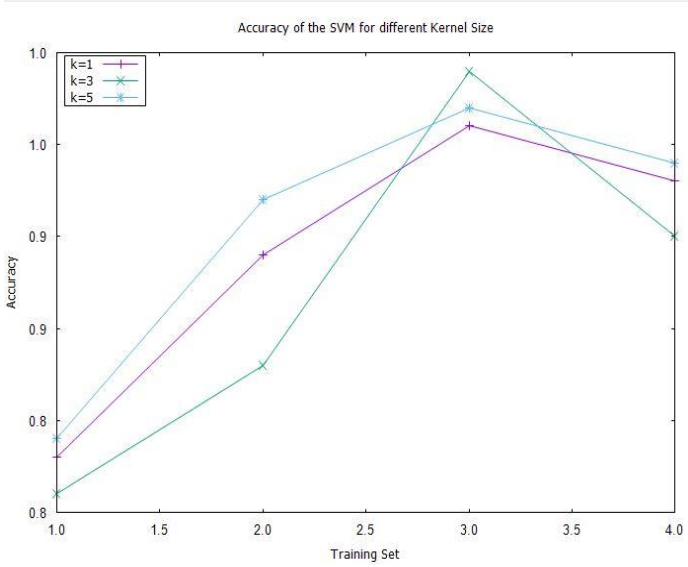

Fig. 6. Accuracy comparison of SVM in different sessions

B. Training Results of ANN Alphabets classifier

This ANN is trained to classify the alphabet into individual categories. Hence, this ANN is trained only for the alphabet dataset. The HoG feature map of complete alphabet dataset is obtained using feature extraction procedure as explained in previous section. Total 64 classes are defined into target vector. These 64 classes include 10 vowel, 42 consonants and 12 form of consonant. The target vector includes 556 targets corresponding to each image in the alphabet dataset. The ANN is trained for different number of hidden layer, and different number of samples on three phase's namely training, validation and testing. The table 3 shows the accuracy of the ANN in different training sessions. The number of hidden layers in each session is increased from 5, 10, 20 and 30. Number of the sample images from the datasets is also varies randomly. The accuracy of the neural network in all phases for all types of combinations hidden layers is recorded. This is necessary to obtain the stable neural network model for the given features dataset.

Table 3. Performance of ANN alphabets classifiers during Training sessions

S. No.	Hidden Layers	Training		Validation		Testing	
		Samples	Accuracy	Samples	Accuracy	Samples	Accuracy
1	5	390	83.2	83	52.4	83	49.3
		778	85.3	167	71.6	167	98.6
		1946	84.7	417	70.1	417	45.3
2	10	390	97.2	83	94.3	83	89.5
		778	98.2	167	97.1	167	100
		1946	93.5	417	92.3	417	100
3	15	390	78.6	83	77.9	83	99.6
		778	86.3	167	73.7	167	100
		1946	81.9	417	82.4	417	78.4
4	20	390	69.5	83	78.8	93	82.1
		778	78.4	167	100	93	99.2
		1946	73.8	417	95.5	93	92.3

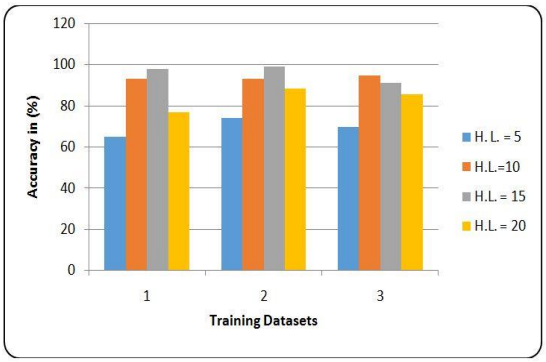

Fig. 6. Accuracy of ANN alphabet classifier during different training session with varying number of hidden layers

During the experiment, the ANN alphabet classifier achieve maximum accuracy i.e. 98.4.% when the number of hidden layers are kept limited to 10. Hence, this ANN is used for further processing.

C.Training Results of ANN Numeral classifier

This ANN is trained to classify the numerals into individual categories. Hence, this ANN is trained only for the numeral dataset. The HoG feature map of complete numeral dataset is obtained using feature extraction procedure as explained in previous section. Total 10 classes are defined into target vector. These 10 classes include numerals from 0 to 9.

Table 4. Performance of ANN numeral classifiers in different Training sessions

S. No.	Hidden Layers	Training		Validation		Testing	
		Samples	Accuracy	Samples	Accuracy	Samples	Accuracy
1	5	28	82.1	6	55.1	6	57.1
		56	83.5	12	69.9	12	68.4
		70	83.1	15	73.1	15	53.6
2	10	28	96.8	6	92.6	6	89.3
		56	94.4	12	93.2	12	91.4
		70	93.5	15	90.7	15	100
3	15	28	98.6	6	96.5	6	98.7
		56	98.3	12	99.7	12	99.1
		70	91.7	15	94.2	15	87.1
4	20	28	73.5	6	77.4	6	79.5
		56	74.7	12	98.7	12	91.3
		70	72.4	15	94.1	15	90.7

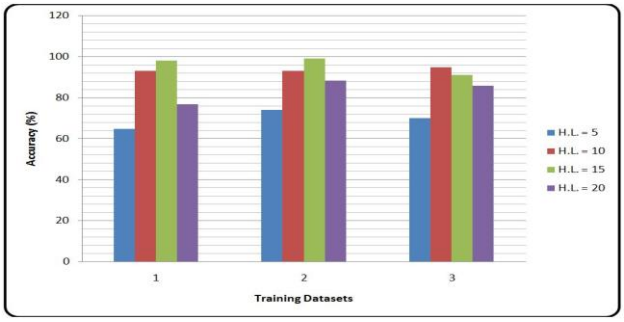

Fig. 7. Accuracy of ANN numeral classifier during different training session with varying number of hidden layers

The target vector includes 100 targets corresponding to each image in the numeral dataset. The ANN is trained for different number of hidden layer, and different number of samples on three phase's namely training, validation and testing. Table 4, shows the accuracy of the different numeral classifier ANNs. The number of hidden layers in each session is increased from 5, 10, 20 and 30. During the training, the highest accuracy of the ANN is recorded in 15 hidden layer for second dataset consisting of total 80 samples. This neural network achieves average accuracy 99.03%. We adopt this model in final classification model.

The proposed hybrid machine learning model improves the overall performance of the license plate recognition. This machine learning model can also be used for recognition of English license plate by proper training.

V. CONCLUSION

This paper proposes an ANPR approach for Hindi license plate recognition. The approach proposed is this paper is based on the hybrid machine learning model that is composing of SVM, ANN alphabet classifier and ANN numeral classifier. The first phase of proposed ANPR approach is character segmentation. The proposed character segmentation approach is able to segment characters from single line and multiline license plates. The average accuracy of proposed character segmentation approach is 98.5%. The license plate recognition accuracy of proposed is 98.7%. Hence, the proposed approach is able to recognize Hindi license plate accurately. The approach proposed in this paper can extend the existing ANPR system to enhance the domain of ANPR system.

REFERENCES

1. S. L. Chang, L.S. Chen, Y.C. Chung, and S. W. Chen, . "Automatic license plate recognition*". IEEE transactions on intelligent transportation systems*, 5(1), 42-53 (2004).
2. T. H. Wang, F.C. Ni, K.T. Li, and Y. P. Chen, "Robust license plate recognition based on dynamic projection warping". *In Networking, Sensing and Control, 2004 IEEE International Conference on* (Vol. 2, pp. 784-788) (2004).. IEEE.
3. A. Capar, and M. Gokmen, "Concurrent segmentation and recognition with shape-driven fast marching methods". *In Pattern Recognition, 2006. ICPR 2006. 18th International Conference on* (Vol. 1, pp. 155-158) (2006). IEEE.
4. N. K. Ibrahim, E. Kasmuri, N. Jalil, M. A. Norasikin, S. Salam,, & M. R. M. Nawawi, "License plate recognition (LPR): a review with experiments for Malaysia case study". *arXiv preprint* arXiv:1401.5559 (2014).
5. N. Vishwanath, S. Somasundaram, S.,A. Nishad, and N. K. Nallaperumal, "Indian license plate character recognition using Kohonen Neural Network". *In Computational Intelligence & Computing Research (ICCIC), 2012 IEEE International Conference on* (pp. 1-4) (2012). IEEE.
6. A. H. Ashtari, M. J. Nordin, and M. Fathy, "An Iranian license plate recognition system based on color features". *IEEE Transactions on Intelligent Transportation Systems*, 15(4), 1690-1705 (2014).
7. T. Kumar, S. Gupta, and D. S. Kushwaha, "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. F. W. Stentiford., "Automatic feature design for optical character recognition using an evolutionary search procedure," *IEEE transactions on pattern analysis and machine intelligence*, no. 3, pp. 349–355,(1985).
9. V. Patil, R. V. Sanap and R. B. Kharate, " Optical character recognition using artificial neural network" *In International Journal of Engineering and Research , General Sci*, vol. 3, no. 1, 2015.
10. S. Ahmad, B. Boufama, P. Habashi, W. Anderson and T. Elamsy, "Automatic license plate recognition: A comparative study", *in 2015 IEEE International Symposium on Signal Processing and Information Technology (ISSPIT)*, pp. 635–640 (2015).
11. A. Rabee and I. Barhumi, " License plate detection and recognition in complex scenes using mathematical morphology and support vector machines". *In Systems, Signals and Image Processing (IWSSIP), 2014 International Conference on* (pp. 59-62) (2014). IEEE.
12. X. Glorot and Y. Bengio, "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. S. Iamsa-at and P. Horata, "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. K. Suzuki, I. Horiba, and N. Sugie, "Linear-time connected-component labeling based on sequential local operations". *Computer Vision and Image Understanding*, 89(1), 1-23 (2003).
15. N. Dalal, B. Triggs, "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. D. P. Mandic, "A Generalized Normalized Gradient Descent Algorithm". *IEEE Sig. Proc. Letters.* Feb;11(2):115-8. (2004).
17. A. Krishnarao, H. Gahlot, A. Srinet, and D. S. Kushwaha, "A comparative study of named entity recognition for hindi using sequential learning algorithms". *In IEEE International on Advance Computing Conference, 2009. IACC 2009*. l pp. 1164-1169 (2009).

AUTHORS PROFILE

Nikita Singh is graduated from AKTU lucknow in CSE in 2015. She complete masters in CSE from Banasthali University Rajasthan, India in 2018. She is currently pursuing Ph.D. degree in Computer Science and Engineering at National Institute of Technology Raipur, Raipur, India. Her research interests include image processing, computer vision and blockchain technology. She has published over 05 SCI and Scopus indexed research articles in International conferences and Journals.

Tarun Kumar received his Bachelor's degree in Computer Science and Engineering from University of Rajasthan, India in 2008 and M.Tech. in Software Engineering from Rajasthan Technical University Kota, India in 2014. He is currently pursuing Ph.D. degree in Computer Science and Engineering at Motilal Nehru National Institute of Technology Allahabad, Allahabad, India. His research interests include image processing, distributed computing and blockchain technology. He has published more than 14 research articles in various SCI and Scopus indexed journals and conferences.

Shrabani Mallick received Ph.D. in Computer Science and Engineering from Motilal Nehru National Institute of Technology Allahabad, Allahabad, India in 2014. She is now working in department of computer science and engineering, Dr. B. R. Ambedkar Institute of Technology Port Blair, India as Assistant Professor. She is author of various articles published in international and national publishers. Her research interest includes service oriented architecture, cloud computing and image processing.