Soft Computing Techniques Based Automatic Licence Plate Recognition Systems for Indian Vehicles

Nitin Sharma, Pawan Kumar Dahiya, Baldev Raj Marwah

Abstract*: Automobile industries are growing exponentially in last decade in India. Growth in the vehicle numbers results in much more road accidents and traffic management problem. Not only this, long queues at toll plazas and parking lot is also a major issue of concern. Problem of traffic management and long queues can be solved by automatic licence plate recognition systems. In this paper, an automatic Licence Plate Recognition Systems based on soft computing techniques are presented. Indian vehicle with licence plates were used for testing the implemented systems. Firstly the licence plate image is extracted from the vehicle image and the characters are segmented from the extracted licence plate image and then features are extracted from the segmented characters which are used for the recognition. Soft computing techniques random forest, neural network, support vector machine, and convolutional neural network are used for the implementation pusrpose. The results obtained for the applied soft computing technique are compared to the last. The future scope is the hybrid technique solution to the problem.

Keywords* : Automatic License Plate Recognition System (ALPR), Convolutional Neural Network (CNN), Neural Network (NN), Random Forest (RF), Support Vector Machine (SVM).

I. INTRODUCTION

Traffic chaos is one of the biggest problems in a developing country. India with a huge population, limited roads, and infrastructure is facing the same problem. Traffic problem leads to the loss of time and money both. Intelligent Transportation System is the solution to the discussed problem. ITS implementation results in a solution to the Traffic Management, Parking Solutions, Automatic Toll Collection, Traffic Security, Traffic Rule Enforcement etc. [1].

The process of toll collection must be fast in order to save time and fuel both. There are 462 toll plazas in India acorss the country. Long waiting at toll counters leads to loss of individual time as well as money. An ALPR system is used to do the processing fast. In ALPR system, firstly the image of the vehicle is taken and the vehicle licence plate region is separate from it. Secondly, the extracted licence plate region is processed to segment the characters of the licence plate. Lastly, the segmented characters are recognized [2][3].

A number of soft computing techniques have been implemented for various applications and these techniques are doing well also[4]. Here soft computing techniques such as Random Forest (RF), Neural Network(NN), Support Vector Machine (SVM), and Convolutional Neural Network (CNN) are suggested for Indian licence plate recognition systems. The main contribution of the paper is as follows:

- The RF, NN, SVM, and CNN based ALPR systems are implemented and tested for Indian licence plates.
- The different implemented techniques are compared on the basis of performance rate.
- The future trend of the techniques for ALPR systems is also discussed.

The rest of the paper is organized as follows. In the section, II ALPR system is introduced. Section III discusses the implemented techniques. Section IV discusses, the methodology used and section V discusses results, discussions and comparison of various implemented ALPR techniques. In section VI, we conclude this paper and discuss the future directions.

II. ALPR SYSTEM

An ALPR System, input image of the vehicle is preprocessed through a number of steps. After preprocessing the licence plate characters are segmented. The features of segmented characters are extracted and these extracted features are used for the recognition of the segmented characters [5]. The steps involved in the process are shown in fig. 1.

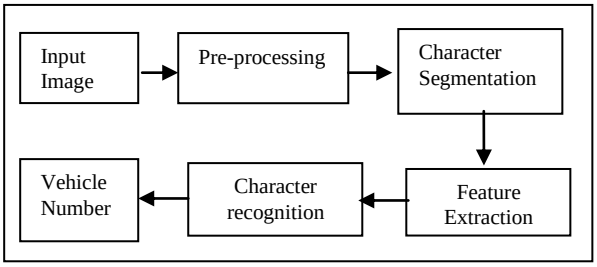

Fig 1 An typical ALPR system.

A country like India, there is a high accident rate which can be controlled only through law enforcement. Secondly, the long queue on toll counters results in wastage of resources and time. An ALPR system which can correctly recognize the vehicles in small time is needed to solve the said problems. A number of ALPR systems are reported in the literature but their recognition rates are need to be improved upon.

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III. VARIOUS IMPLEMENTED ALPR TECHNIQUES

In the implemented work, the prepossessing of the vehicle image involves steps like filtering, dilation, labeling, connected components and histogram. These steps are used to find the licence plate in the image. After that the connected components are separated. The features of the separated characters are extracted and given futher for the recognition. The following four recognition techniques are used to get the results.

A. Random Forest

RF algorithm [6]is a popular technique used to build machine learning systems. It is a supervised machine learning technique proposed by Leo Breiman [6]. RF is an ensemble algorithm. An ensemble consists of a set of individually trained algorithms, also known as base algorithms, whose predictions are combined when predicting new instances. RF uses decision tree as a base algorithm. It generates several decision trees and combines outcomes of these decision trees as the final result. RF is a supervised classification algorithm. The accuracy of classification depends on the number of trees. In this algorithm a forest is created with the number of trees [7]. It introduces randomization in two ways: firstly random sampling of data to generate bootstrap samples and secondly random selection of input features / attributes. When RF is used for classification, the outcomes of base decision trees are combined by majority voting to give outcome of the forest. Strength of individual decision trees and correlation among these trees are key issues which decide generalization error of RF classifier [6].

B. Neural Network

An ANN is inspired by the human brain. Like the human brain consists of neurons, the ANN model is an interconnection of artificial neurons called nodes. The inputs to the artificial neuron are the signals it receives from its predecessor's nodes. The input of the node is given by the mathematical equation:

$$P_j(t) = \sum_i O_i(t) W_{ij} \quad (1)$$

Where,

$P_j(t)$ is the input to the j_{th} node from its preceding nodes.

$O_i(t)$ is the output of the predecessor nodes of the network.

W_{ij} is the weight of the branch between the i_{th} and j_{th} node

The input calculated by above equation is given to the activation function of the j_{th} node to obtain the final output of the j_{th} node. The NN work updates its interconnection weight during learning and thus able to learn the input out relationship. Feedforward NN and Self-organizing Map network are the used for pattern classification applications and data cluster and feature mapping applications respectively.

C. Support Vector Machine

SVM is a machine learning technique in which model is trained for the classification application. It is a supervised learning model that uses the training data for the classification and regression analysis. The training dataset along with its labels are used to train the SVM model. The trained model assign each new input applied to one or the other category as a non-probabilistic binary linear classifier [8]. An SVM model is a representation of the data sets as points in space, mapped so that the data sets of the different categories are separated by hyper plane. The gap between the dividing plane and data set is maintained as wide as possible. Now when a new input given is then mapped to the same space and predicted to belong to one of the category based on which side of the hyper plane they fall. However, A multiclass classifications problem can also be solved by a few support vectors effectively [9].

D. Convolutional Neural Network

A typical CNN is a multi-layer structure. The first layer is the input layer to which image to be classified is given. The convolutional layer is the second layer and it is called so because filtering operation is done by a feature map is a discrete convolution [10]. The input image to be classified is convole with the number of filters. After each convolution layer, conventional Rectified Linear Units Layer (ReLU) is in the architecture to have nonlinearity in the system [11]. The ReLU layer set all the negative value elements to zero [12], i.e.,

$$f(x) = \begin{cases} x, x \geq 0 \\ 0, x < 0 \end{cases} \quad (2)$$

Next layer is used to do down sampling; it is achieved by pooling layer. The fifth layer used is a fully connected layer. The sixth layer of the network is a softmax layer. For a classification problem with more than two classes, the output unit activation function is the softmax function [13]:

$$P(c_r/x, \theta) = \frac{P(x, \theta/c_r)P(c_r)}{\sum_{j=1}^{k} P(x, \theta/c_j)P(c_j)} = \frac{\exp(a_r(x,\theta))}{\sum_{j=1}^{k} \exp(a_j(x,\theta))} \quad (3)$$

Where $0 \leq P(c_r/x, \theta) \leq 1$ and $\sum_{j=1}^{k} P(c_j/x, \theta) = 1$

Moreover, $a_r = \ln (P(x, \theta/c_r)P(c_r)$

$P(x, \theta/c_r)$ is the conditional probability of the sample given class r, with $P(c_r)$ is the class prior probability. The seventh layer is the classification layer [14] [15].

IV. METHODOLOGY

In India, a number of fonts such as Arial, Bookman Old Style, Calibri, Cambria, Consolas, Lucida Bright, Lucida Console, Rockwell, Tahoma, Times New Roman, Verdana etc. are used in writing licence plates. This non-uniformity in the Licence Plate may lead to the different features for the same character and if this point is ignored then this may result to wrong recognition. Here, different fonts have been considered for the training purpose.

Fig. 2. Images of Licence plates with different fonts consider for the testing purpose.

Indian licence plate contains English alphabets and numbers. The two data sets 572 samples of the English alphabets and 220 samples of numbers are used for training purpose. The feature of these samples is extracted and used for the training of the recognition modules. Then these trained modules are used for the recognition of testing dataset which consists of images of Indian cars under different conditions. Here, recognition modules based on soft computing techniques that are RF, NN, SVM and CNN are implemented for the recognition of the characters and are briefed as follows.

A. Random Forest Module

The feature of (1*35) is extracted for each character. These extracted features are used to train the RF module. Using this trained RF module the results obtained are 88.5% for the alphabets and 93% is for the numerals with an overall recognition rate of 91.2%.

B. Neural Network Module

NN module consists of two feed-forward backpropagation neural networks. The feature of the segmented characters is extracted and given as the input to the feed forward neural networks. The first NN is used for the recognition of English alphabets while the other one is used for the recognition of numerals. The size of three layers neural network used for the recognition of English alphabets is 35*200*26 while the size of another three-layer neural network used for the recognition of numeral is 35*200*10. The two neural networks are trained for 1144 alphabets and 440 numerals. The trained NNs are the tested for the 50 different images of Indian licence plates and the results obtained are 90.5% for the alphabets and 93.67% is for the numerals with an overall recognition rate of 92.4%.

C. Support Vector Machine Module

The feature of (1*25) is extracted for each character. These extracted features are used to train the SVM network. Using this trained SVM model the results obtained are 92% for the alphabets and 95% is for the numerals with an overall recognition rate of 93.8%.

D. Convolutional Neural Network Module

The CNN module is a seven-layer structure. The input to the first layer of CNN is segmented characters images of size 28*28. The second layer which is a convolution layer consists of 20 filters with size 9*9. After this, the threshold function is performed by the third layer of CNN that is rectified linear unit. The fourth layer is used to find the element with the maximum value in the pool. The pool size set is 2*2. The fifth layer used is a fully connected layer. The sixth layer of the network is a softmax layer. The seventh layer is the classification layer. the results obtained are 93.5% for the alphabets and 96.33% is for the numerals with an overall recognition rate of 95.2%.

V. RESULTS AND DISCURSSIONS

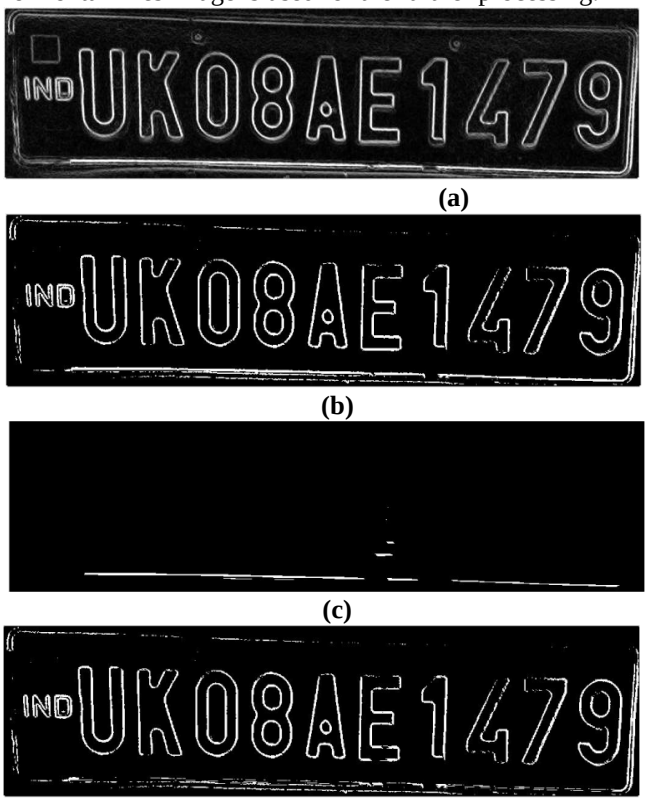
The algorithm is run over a number of input Indian licence plate images. The outputs obtained at various steps are as described below. The image of the car is given as input. Then the input image is converted into a black and white image

(a)

(b)

Fig. 3. Input Images (a), Black and White Image (b).

Now, Sobel filter is used to find out the edges of the input image. Then the intensity scaling of the image is done. After that horizontal lines are detected in the intensity scaled image. The difference of the intensity scaled image and the horizontal lines image is used for the further processing.



(a)

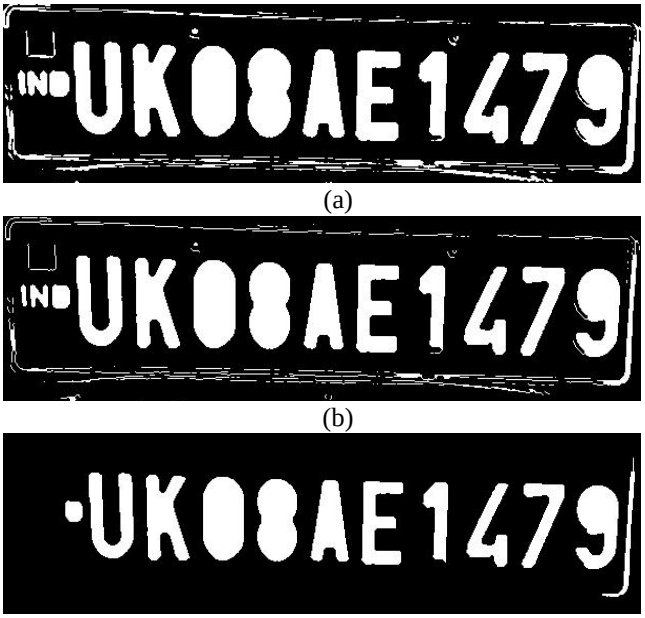
(b)

(c)

(d)

Fig. 4. Edge Detection of BW image (a), Intensity scaling (b), Horizontal lines detection in Image (c) and subtracted image (d).

Now the holes in the input binary image are filled. Here, a hole is a set of background pixels that cannot be reached by filling in the background from the edge of the image. The next step in processing is the thinning of the connected components of the image. Now all the regions having more than 300 pixels are kept rest are discarded.



(a) (b) (c)

Fig. 5. Filling of the region (a), Thinning of the image for isolation (b), and Removal of the region (c).

From the resultant image obtained from the last step, the characters are separated and segmented on the basis of the position of their starting pixel, height, and width.

Fig. 6. Segmented characters from the input image.

The last step left is the recognition of the segmented characters, for which three soft computing techniques are used. Features are extracted and are given to the NN, SVM and CNN network to get the recognized characters.

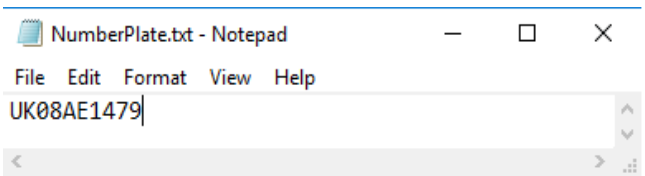


Fig. 7. Recognized Number of Indian Licence Plate

The techniques were implemented in MATLAB 2017. The trained network used for the recognition of 500 characters of the licence plate. The results obtained are as follows:
The number of Licence plates tested is 50.

Table- I: Accuracy of Implemented Techniques

Technique Used	Accuracy					
	Alphabets Recognized		*Numeral Recognized*		*Overall*	
	Out of 200	in %	Out of 300	in %	Out of 500	In %
RF	177	88.5	279	93	456	91.2
NN	181	90.5	281	93.67	462	92.4
SVM	184	92	285	95	469	93.8
CNN	187	93.5	289	96.33	476	95.2

The recognition rate of alphabets in case of RF, NN, SVM, and CNN based ALPR systems are 88.5%, 90.5%, 92%, and 93.5% respectively. The recognition rate of numerals in case of RF, NN, SVM, and CNN based ALPR systems are 93%, 93.67%, 95%, and 96.33% respectively. The overall accuracy of the RF, NN, SVM and CNN based ALPR systems are 91.2%, 92.4%, 93.8% and 95.2% respectively.

VI. CONCLUSION

In this work, ALPR systems based on RF, NN, SVM, and CNN are presented. It has been observed from the results obtained that recognition rate obtained for the CNN based ALPR system is having edge over other two soft computing techniques. The recognition rate obtained for the CNN based ALPR system is better at 4%, 2.8% and 1.4% than the RF, NN and SVM based ALPR system respectively.

In India, a number of formats are used for the licence plates. Due to which the accuracy obtained here is low. However, if a standard format is used in that case the accuracy can be obtained much higher. A further hybrid technique based on soft computing can be implemented. RF hybrid with CNN, CNN hybrid with SVM can be implemented and tested for Indian licence plates in order to obtain the better results.

REFERENCES

1. S. Du, M. Ibrahim, M. Shehata, and W. Badaway, "Automatic License Plate Recognition (ALPR): A State-of-the-Art Review," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 23, no. 2, pp. 311–325, 2013.
2. P. Kulkarni, A. Khatri, B. P., and K. Shah, "Automatic Number Plate Recognition (ANPR)," *2009 19th Int. Conf. Radioelektronika*, pp. 111–114, 2009.
3. S. Kranthi, K. Pranathi, and A. Srisaila, "Automatic Number Plate Recognition," *Int. J. Adv. Technol.*, vol. 2, no. 3, pp. 408–422, 2011.
4. V. Kamat and S. Ganesan, "An efficient implementation of the Hough transform for detecting vehicle license plates using DSP'S," in *Real-Time Technology and Applications Symposium*, 2002, pp. 58–59.
5. C. E. Anagnostopoulos, "License Plate Recognition : A breif tutorial," *IEEE Trans. Intell. Transp. Syst. Mag.*, vol. 6, no. 1, pp. 59–67, 2014.
6. L. Breiman, "Random Forests," *Mach. Learn.*, vol. 45, no. 1, pp. 5–32, 2001.
7. T. K. Ho, "Random Decision Forests," in *Proceedings of 3rd international conference on document analysis and recognition*, 1995, pp. 278–282.
8. C. Cortes and V. Vapnik, "Support-Vector Networks," *Mach. Learn.*, vol. 20, no. 3, pp. 273–297, 1995.
9. C. W. Hsu and C. J. Lin, "A comparison of methods for multiclass support vector machines," *IEEE Trans. Neural Networks*, vol. 13, no. 2, pp. 415–425, 2002.
10. Y. Lecun, L. Bottou, Y. Bengio, and P. Haffner, "Gradient based learning applied to document recognition," *Proc. IEEE*, vol. 86, no. 11, pp. 2278–2324, 1998.
11. Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," *Nature*, vol. 521, no. 7553, pp. 436–444, May 2015.
12. D. Menotti, G. Chiachia, A. X. Falcão, and V. J. Oliveira Neto, "Vehicle license plate recognition with random convolutional networks," in *Vehicle license plate recognition with random convolutional networks. In 2014 27th SIBGRAPI Conference on Graphics, Patterns and Images*, 2014, pp. 298–303.

13. A. Krizhevsky and G. E. Hinton, "ImageNet Classification with Deep Convolutional Neural Networks," *Adv. Neural Inf. Process. Syst.*, pp. 1097–1105, 2012.
14. V. Jain and S. Biswas, "Deep Automatic Licence Plate Recognition system," in *Proceedings of the Tenth Indian Conference on Computer Vision, Graphics and Image Processing*, 2016, p. 6.
15. K. K. Kim, K. I. Kim, J. B. Kim, and H. J. Kim, "Learning-based approach for license plate recognition," in *In Neural Networks for Signal Processing X. Proceedings of the 2000 IEEE Signal Processing Society Workshop*, 2000, vol. 00, no. C, pp. 614–623.

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