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Automatic License Plate Recognition using Video Sequences as Input and Artificial Neural Network as Recognition Technique

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Abstract

ALPR system is used to automatically extract the number plate of a vehicle. This can be achieved by using different techniques that are employed in the field of image processing. ALPR method consists of 4 basic stages. The first stage of the system is the acquisition of an image of the vehicle. After that, the next step is license plate localization and then segmentation of the extracted license plate is done. And finally, the last step is the recognition of the characters. In this paper, recognition of characters is done by Artificial Neural Network (ANN) is presented. Further, the future scope is described, which can be best served for the researchers.

Keywords: *Artificial neural network (ANN), automatic license plate recognition system (ALPR), Video Sequences, segmentation, Character recognition.*

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INTRODUCTION

ALPR plays a significant role in different applications like road traffic monitoring the parking lots, in toll collection and in traffic law enforcement system [1-5]. ALPR identifies a vehicle's number plate from video input taken by two different cameras either color or black & white camera. ALPR also called as optical character recognition (OCR), automatic car number recognition, vehicle identification system, number plate recognition system for cars. Various challenges are available in the field of ALPR in detection and recognition of plate. ALPR consists of 4 stages for license plate detection [6]. Firstly, a vehicle's video is captured by a camera and after that, a suitable image is acquired from the different frames of that particular video. After that, all preprocessing steps are followed by the extraction of the plate number of the vehicle. The characteristic of videos varies as per the features of cameras used. The camera quality should be high so that system will provide good results. Illumination condition also affects the characteristics of the captured video [3, 5].

The next step removes unnecessary background region of the images, so the license plate is extracted. After this, the next step is segmentation, in this number plate is segmented & the plate characters are extracted. The last step is recognition of the vehicle's number. Figure 1 describes the block diagram of the ALPR. Figure 2 shows a flow chart of the ALPR system.

There are several papers on this field which provides a survey of different existing techniques that can be used for identification, segmentation, and recognition of the number plate of a vehicle in terms of their pros and cons. In this paper, work is presented on the image acquisition, image extraction, character segmentation and character recognition.

There can be many objectives in the ALPR system. By improving the number plate localization algorithm, the system performance may be increased. There can be many algorithms that can be used for localization like a genetic algorithm. The objective of the presented work is to design the algorithm for

the localization and recognition of the plate which has the following features:

- To extract a correct frame that having a clear number plate especially when the vehicle speed is very fast.
- To remove the influence of lighting and to make the number plate salient, image enhancement method is used for good preprocessing.
- To improve recognition rate, the objective is to concentrate to improve on the burst characters and ambiguous characters, like (K-X), (O-0), (B-8), (I-1), (C-G), (D-O), (A-4) *etc.*
- Thus, this proposed method is framed by taking care of the limitations with the earliest technologies also as being a part of the future directions, the work also throws open interesting offshoots.
- Importance and contributions of the current work are listed as under:
- Image acquisition problem in ALPR is fully detailed along with a discussion on state-of-the-art acquisition techniques.
- Reviewing the state-of-the-art techniques used in this field.
- A novel modeling approach used for the recognition and localization of license plate.
- Probing the future techniques for complete identification of license plate which can adapt the lesser number of limitations that existing in the earlier work.
- Reviewing the early and recent developments in this field.

In a nutshell, it may be summed up that the current work not only gives an insight to the existing ALPR system but also looks into another efficient techniques that can be used for implementing the system in practical utility.

The paper, also, consists of some limitations of the existing system, which can be foreseen, for the researchers for further improvement in the ALPR system. In the next section, the character recognition technique known as Artificial Neural Network is described. In the next section, we describe, how ANN is used in the recognition process. This section also consists general overview of tool to be used to implement this system. After that results and discussions, sections are summarized. In the last section, conclusion and future direction of the ALPR system are presented.

ARTIFICIAL NEURAL NETWORK

The ALPR consists of mainly 4 steps named as license plate localization, license plate extraction, character segmentation and character recognition. Character Recognition deals in classification and characters recognition from the image of the vehicle. Some geometrical and topological properties are calculated and these properties are used for the recognition process. The accuracy of the recognition process depends upon these properties. Some features such as enclosures, curves, protrusions, strokes, shape of characters are very helpful for a human being to perceive the characters.

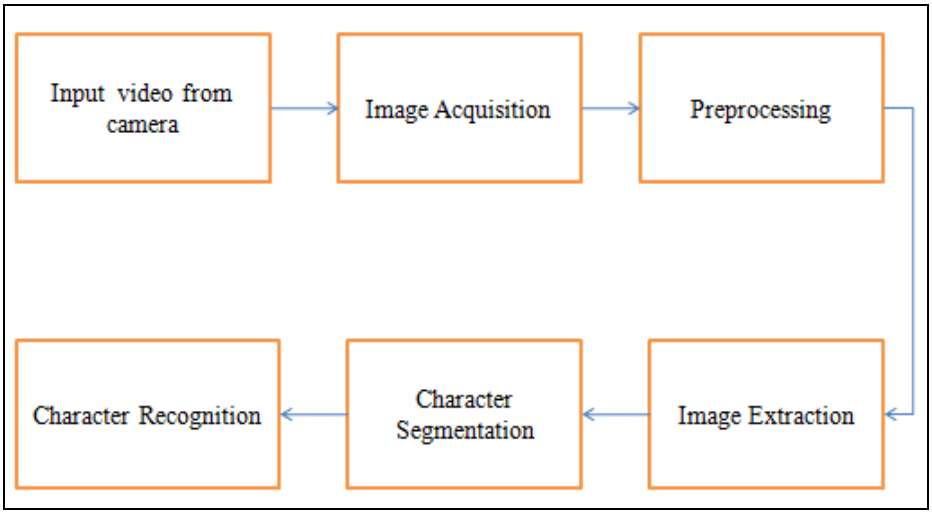

Fig. 1: *Block Diagram of ALPR.*

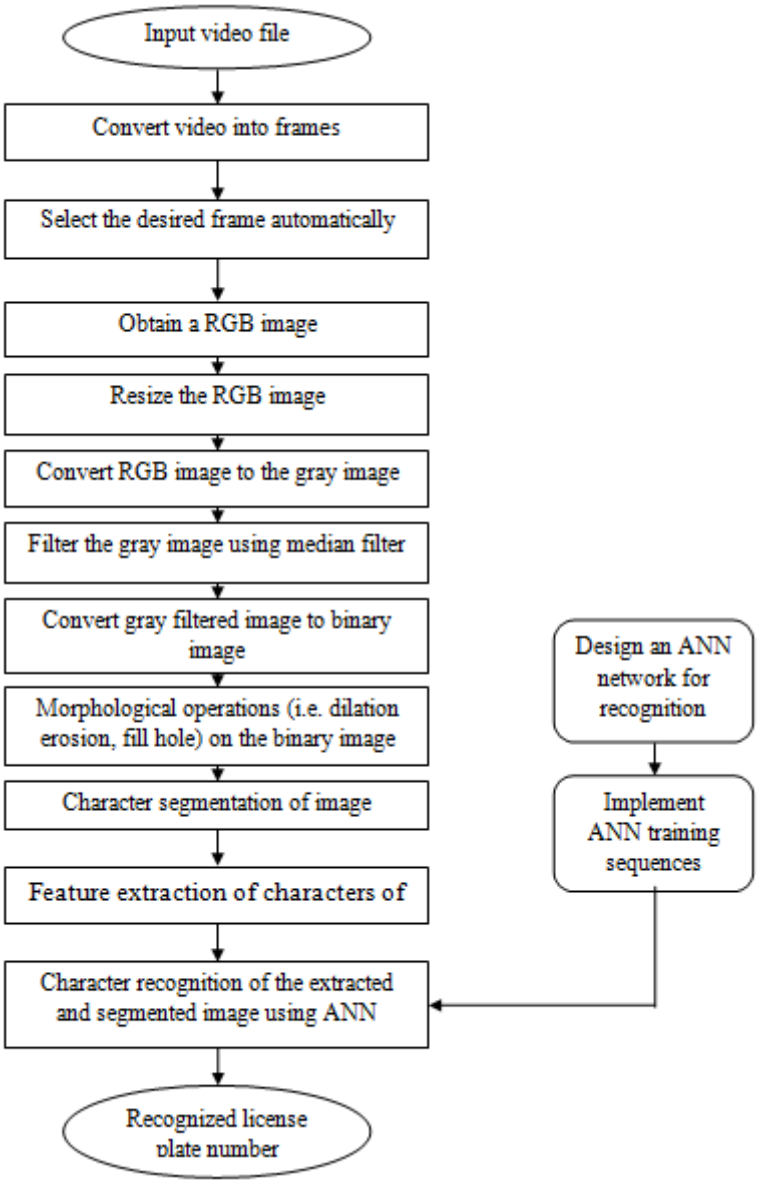

Fig. 2: *Basic Structure of System.*

Spatial pixel based calculation is used for extraction of these features. The combination of these features is known as Vectors. A recognition technique such as Artificial Neural Network uses these features for recognition of characters [7].

The extracted characters, obtained in the segmentation stage are recognized using ANN. ANN is usually called neural network. This network is inspired by functional aspects of biological neural networks and the structure. ANN is a similar concept as Biological Neural Network (BNN). Neurons are the basic building block of the BNN and ANN. Neurons are the atomic components. The ANN consists of some features and characteristics of the BNN. The ANN is just like the reproduction of the BNN [8]. The ANN is used for the various applications for the completion of the task. The ANN works in a nonlinear fashion. Human activities depend upon the set of neurons, which are present in the human brain. These neurons have formed a network in the human brain. The cyton and axon are the cell body which forms the neuron or a nerve cell. Information between neurons is transmitted with the help of electric impulses [9].

Figure 3 shows the structure of the neural network in the human brain. The ANNs follow the same working principle as a human neural

network [9, 10]. The input functions are summed up in the ANN. The resultant sum is the basic thing, which determines the network's strength. There are many activation functions, which can be used in the ANN for the better response of the system. The sum is being served as the input for the activation function. Generally, sigmoid activation function is used to get providing effective results. Value of output of a sigmoid activation function lies between 0 and 1. After this, few connections are used to pass the resultant, of the activation function, which serves as the input for other weighted neurons [10]. There are many processing elements presents in the ANN system. These processing elements work in an appropriate manner to solve any problem. There are three layers presents in the neural network such as input, output and hidden layer. Three layers N/W is shown in Figure 4 [11].

The ANN can be used in different applications such as data classification or pattern recognition technique [12]. Some formal logics are used for initial simulations steps in the ANN. McCulloch and Pitt's model as shown in Figure 5, helps in the understanding of the NNs. The working methodology of the neurons is clearly explained in the McCulloch and Pitts model [12].

The working concept of the model is based on the simple neurons. When this model is introduced with simple neurons, they were treated as the binary devices, with a fixed threshold. The output of the model was in the form of a binary logic function [12]. Neuron McCulloch-Pitts model represented by equation 1 and 2 [12].

In equation (1 and 2), w and x represents weight and input respectively. σ(ζ) represents the function of the weighted sum. There is much architecture that can be used in the ANN. Generally, two architectures named feed-forward network and feedback network or back-propagation is used [11]. In the ANN, training is the fundamental step, for completion of an application. Training of the network is done once and then it can be used in several applications. The trained ANN provides results independently [11]. The ANN can be trained by two methods such as supervised and unsupervised. In the supervised training method, input and output are given. In this training, errors are calculated. In unsupervised training, only input is provided to the network. In this training, the proposed network automatically adjusts itself according to the weights [11]. More recently, Soft Computing Techniques like PSO, ACO, GA, BBO, MA, BFO *etc.* can also be used for character recognition [13].

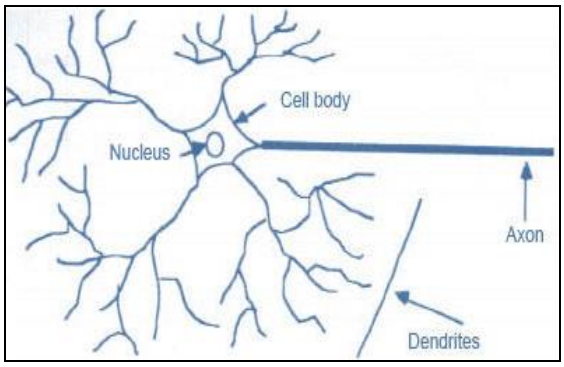

Fig. 3: *Neural Network in Human Brain.*

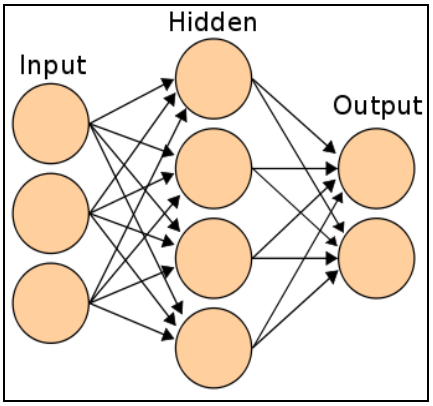

Fig. 4: *Three-layer Neural Network.*

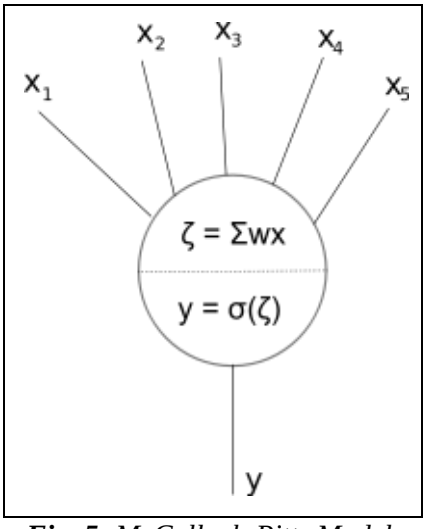

Fig. 5: *McCulloch-Pitts Model.*

$$\zeta = \sum w_i x_i \quad (1)$$

$$y = \sigma(\zeta) \quad (2)$$

ARTIFICIAL NEURAL NETWORK FOR AUTOMATIC LICENSE PLATE RECOGNITION SYSTEM

ALPR system, character recognition is a most significant step. Alphanumeric characters can be easily recognized by using an efficient technique of character recognition. In the recognition process, a determine characters class is needed. A machine should be able to recognize the alphanumeric characters as a human being can. There are many fonts available in the computer system. The best techniques, used for the character recognition, can play a vital role in this recognition process. The recognition techniques have performed a function, just like a bridge in between the human being and the machine tools. Some classical methods are not efficient for the recognition of visual characters [14]. There are various techniques available for character recognition; ANN is one of them and also known as a neural network. Some biological neural network and structure are used for the invention of the ANN technique. Actually, the ANN uses some functional aspects of the biological neural network. Neurons are the main basic building block of the ANN. This neuron helps for determining the values of the ANN. The ANN is trained to perform a particular function. Thus, weights are adjusted.

In this, a comparison is made between the output and target value. According to the need, weights are adjusted to equalize the value of target and output. There is various transfer function which is used in the ANN like tan-sigmoid, log sigmoid, linear transfer function, hard limit transfer function [15]. Due to the size of the extracted characters there exists some problem due to a zoom factor of cameras. Such types of problems overcome by using resizing the image [16]. Recognition of characters can also be done by using a method named as template matching [17–21][22], [20], [18], [14] and [12]. The recognition results obtained by the ANN method are better than the results of the template matching technique.

In the ANN technique, classification of the character is done by using an ANN classifier or multi-layer neural network. In the ANN processing units are the main elements. In this approach mainly three processing units are used [19, 22–24]. First is input layer second is a hidden layer and third is the output layer. Input layer consists of all the information which is used to take a decision. Hidden layer carries the more complicated associations and output layer provides information about results. Series of weights are used to feed neurons from input layer directly to the hidden layer. At each node sum of the product of the weight and input is calculated and serves as input for the output layer. In this process, weights are used to feed the output layer. The neural network is trained if the difference between the output and target value is more than error ratio [4]. In this paper, back propagation network is used for training of the ANN. The efficiency is measured using the terms "regression coefficient". The Mean Square Error (MSE) is also another factor which is used to determine the performance of the network. Designer set the target values to minimize the error rate. The author proposed a method of analysis of license plate using MWT [25]. It has shown a license plate detection using the concept of multiwavelet transform and empirical mode decomposition [26].

In the ALPR system, different fonts of the same digit are trained by Neural Network. The last step of the ALPR system is recognition of characters. After training the ANN on a different set of fonts, the features of segmented characters of detected number plate are captured. These features are the same as that of those which are used for training the ANN. When the extracted features of the segmented character are presented to the trained ANN, then the location of best-matched character is returned by the ANN as a result. Now, these locations are encoded into character values for obtaining the result in the form of character. Computationally intensive tasks can be easily implemented by MATLAB software. This software provides an interactive environment to perform such type of operations. The MATLAB software is much faster than the other languages such as C++, C. In the field of image processing, signal processing, control design communication,

financial modeling or analysis and computational biology, MATLAB software plays an important role. In this paper, all the experiments are performed in MATLAB.

RESULTS AND DISCUSSION

In this paper, a trained ANN is used to recognize the characters. In the ALPR system, the camera captures a few second videos of the vehicle and a system processes this video. Figure 6 shows the input video from the camera. After this, the video is converted into different frames. A frame, which consists of a clear vision of the license plate of the vehicle, is taken out among all frames. Figure 7(a-h) shows different frames of the video file. After this, the number plate is extracted from the frame or image. The plate is extracted using preprocessing methods.

Capturing Video as Input File

First of all, Input video from the camera – at this stage a video is captured from the good quality camera, which serves as the input of the system. A video is a combination of several sequential frames. After this, the video is required to be converting into individual frames. Figure 6 shows the video of the car as an input video file for the ALPR system and Figure 7(a-h) shows the frames of that corresponding video.

Reading a Desired Frame or Image

Among these frames as shown in Figure 7, the desired frame is selected for the further functioning of the system. After that, this image of the vehicle now read by the MATLAB software as an input for the ALPR system. Figure 8 shows the suitable frame or image for the ALPR system.

Resizing Input Image

The video is at the beginning captured by a 12 Mega-pixel digital camera. After reading an image, it is resized to 480x720 for further processing. Figure 9, shows the resized image.

Converting Resized Image to Gray Image

After that, this resized image is converted into the gray image as shown in Figure 10. The true color image RGB is converted into the gray intensity image. A function converts RGB images to gray by eliminating the hue and saturation information while retaining the luminance. After that, a grayscale image is obtained and on this gray image further, pre-processing steps will be performed.

Histogram Analysis

Next step is extracting the number plate region of image and remove the background (*i.e.* undesired region) of the image. Histogram method is used to found the location of the number plate.

Fig. 6: *Video Input File.*

Fig. 7 (a-h): *Different Frames of Video File.*

Edges of an image can be estimated in the horizontal direction as well as in vertical direction using horizontal histogram and vertical histogram. Histogram plays a vital role in spotting the plate number. Both horizontal and vertical histogram is calculated, to detect the number, it represents row-wise and column-wise histogram respectively. The difference of gray values between the neighboring pixels of an image is estimated.

Fig. 8: *Input Image File.*

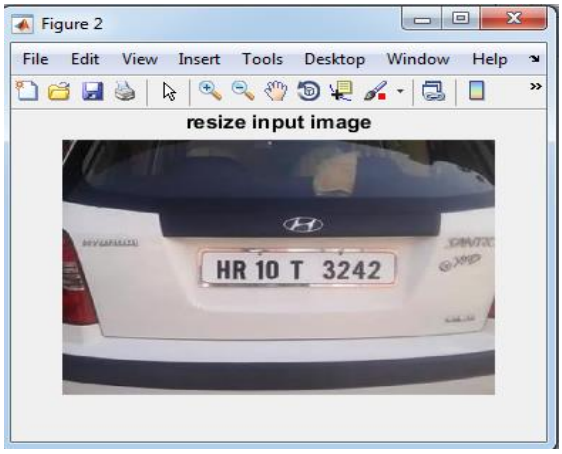

Fig. 9: *Resized Input Image.*

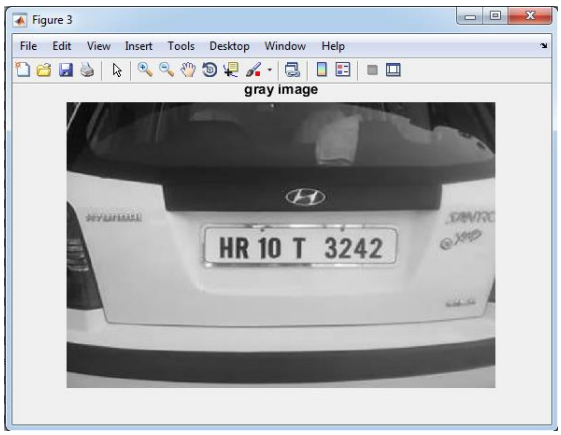

Fig. 10: *Gray Image.*

After that sum of the difference in gray values is an important consideration for both row-wise and column-wise. When a gray image is obtained then this gray image is used as input for the horizontal edge processing step. After that, the vertical edge histogram is obtained. After that, the output of horizontal and vertical edge processing is fed to the smoothening filter. Now there is a need of suppression of smoothened histograms. For achieving this, a low pass filter is used whose cut off frequency is determined first.

After that, the smoothened histogram is sent to the low pass filter. Low pass filter suppresses the undesired values of the histogram which are less than the cut off frequency of low pass filter. Figure 11 and 12, show a horizontal histogram, vertical histogram, horizontal smoothened histogram, vertical smoothened histogram and filtered histogram of the gray image.

Localizing Number Plate of the Vehicle

The main aim of introducing horizontal and vertical histogram for edge processing is to recognize the number plate region. To localize an image, a most powerful method such as thresholding is applied. It is the simplest method to localize an image. The threshold level is fixed according to the requirement. An image contains desired as well as undesired regions or objects. So undesired regions are needed to be deleted or removed from the image. In the earlier step, vertical and horizontal histograms are passed out from a low pass filter to smooth out an image. A filter can also be used to remove this undesired portion of the image. In this paper, this is achieved by finding out that region in the corresponding histogram which contains high edges variation and the little edges variation. High edge change determines that in an image more variations are present. Low edge variation means that this area does not consist of license plate region. Because a license plate is built on the plain plate having same intensity throughout the plate and some characters and numeral digits are present on the plain plate that forms license plate. Otsu method is generally used for calculating the threshold value. This method uses iterations for determining the threshold value. The value of the threshold is obtained by regarding the interclass value smallest.

Figure 14, shows the approximate location of the license plate of the vehicle.

Converting Gray Image to Binary Image

When a localized license plate region is obtained then this gray image is changed over into a binary image. Some morphological operations like erosion and dilation are performed only on binary images. Figure 15, shows the binary image of a corresponding gray image.

Obtaining Edged Image

After this, the next step is to find out the edges of the image. So, a binary image is converted into the edged image. Edge detection is used in the feature detection and feature extraction. Edge detection is used in the field of image processing. There are various methods of edge detection. In the presented work, edges are obtained by using canny edge detection method. Figure 16, shows an edged image of the vehicle.

Dilating an Image Using Structuring Element

In the field of mathematical morphology, dilation performs a vital role. The edged image, which is obtained from the previous step, has weak edges. Weak edges are not able to recognize. To compensate for the effect of the weak edges the operation named as dilation is used. For dilation, a structuring element is needed. The selection of the structuring element is done as per the shape of the edged image. In the dilation operation, a new value is assigned to the corresponding pixel of the image. Edged image obtained in the previous step, has weak edges. Figure 17, shows the dilated Image.

Eroding an Image Using Structuring Element

After that, erosion will be the next step. Erosion reduces the size of the desired things. Small-scale details of a binary image can be removed by using a method named as erosion. The small regions are removed and gaps and holes between different regions become larger. Erosion is used to erase some pixel of an image. A new binary image is obtained after the erosion process. As dilation process, a structuring element is used for erosion process. Structuring elements are such as square, rectangle, ellipse, line *etc*. In this paper, the author used a line as a structuring element. Figure 18, shows the eroded image.

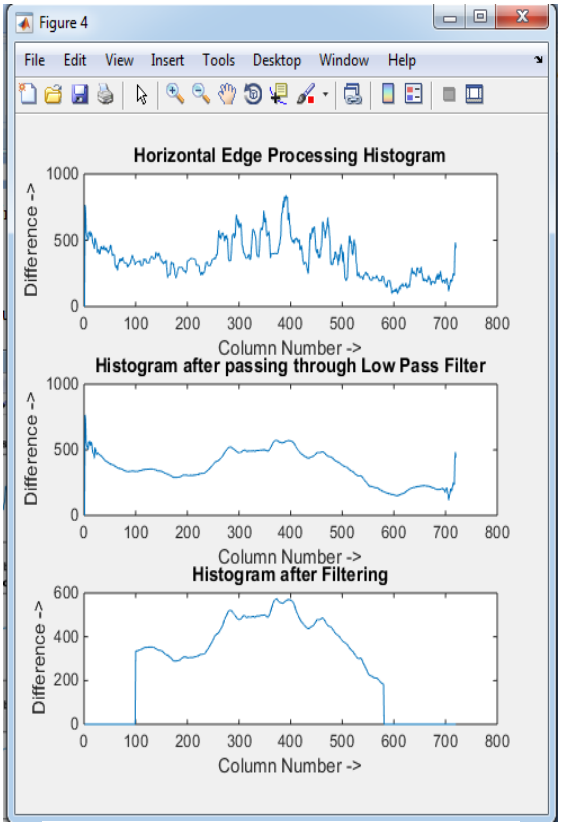

Fig. 11: *Horizontal Histogram Analysis.*

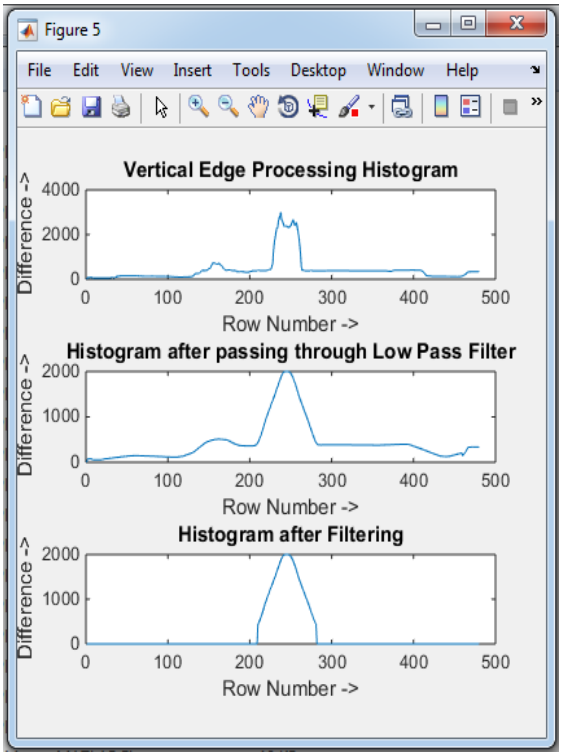

Fig. 12: *Vertical Histogram Analysis.*

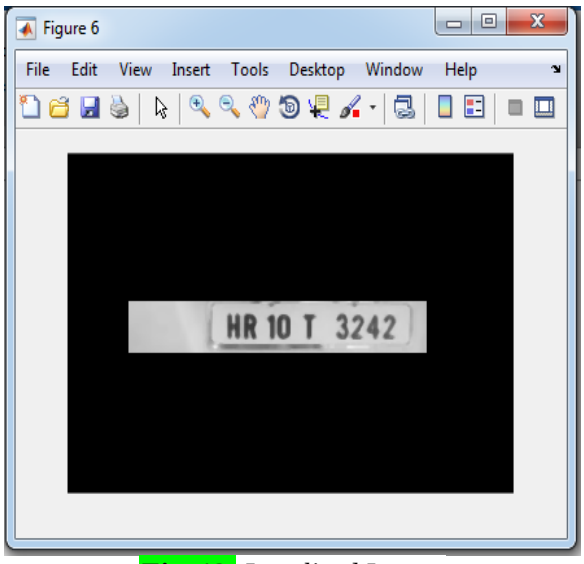

Fig. 13: *Localized Image.*

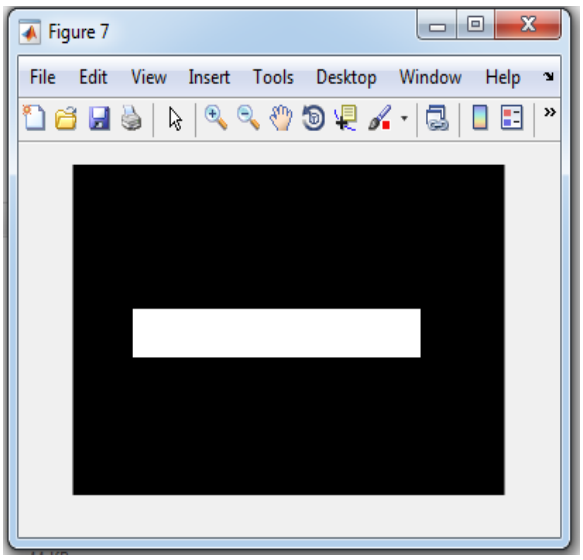

Fig. 14: *Approximate localization of plate region.*

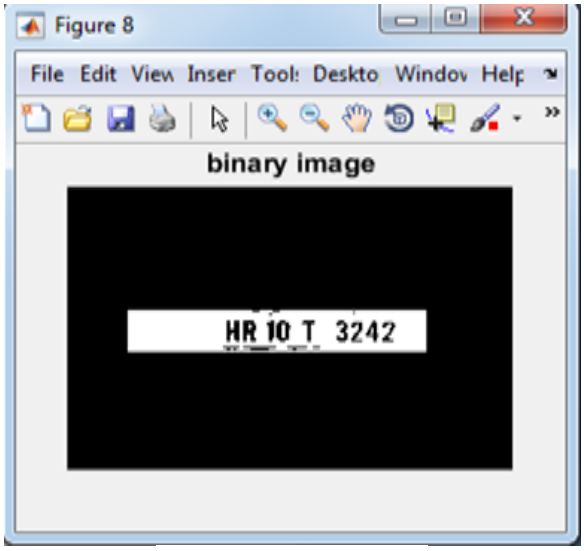

Fig. 15: *Binary Image.*

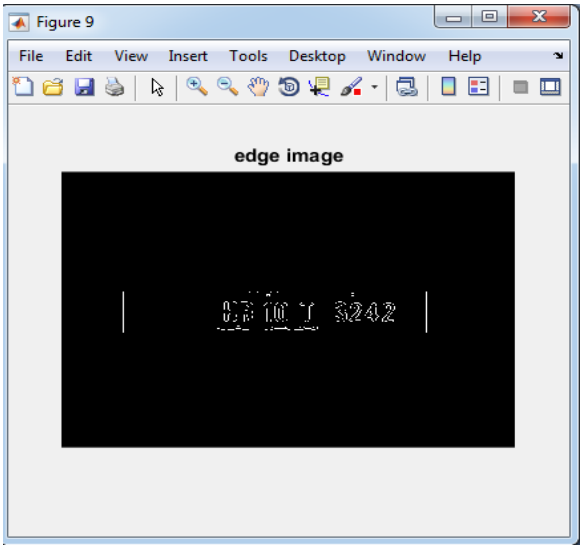

Fig. 16: *Edged Image.*

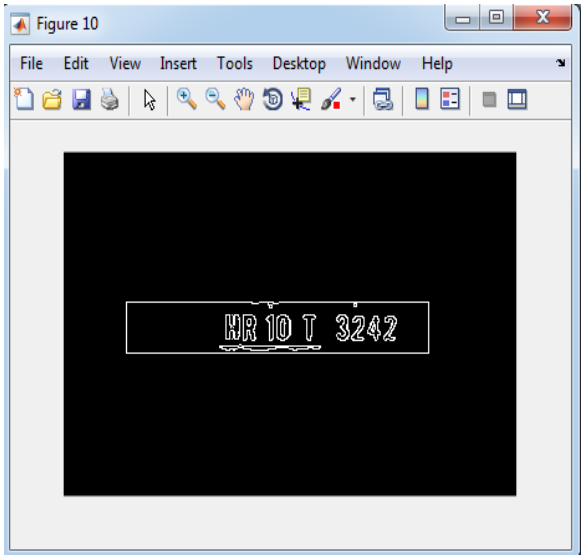

Fig. 17: *Dilated Image.*

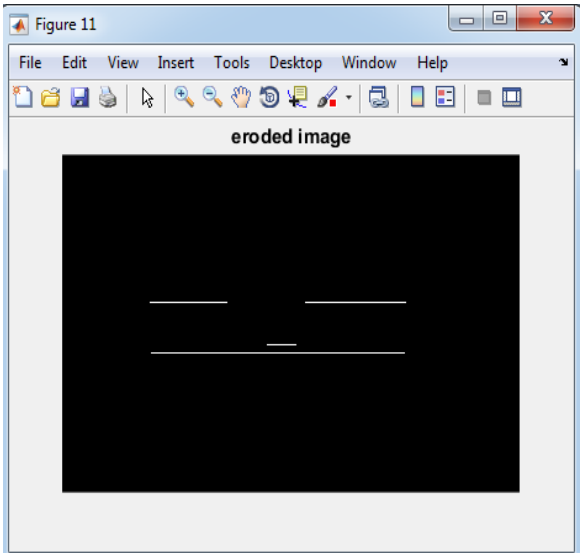

Fig. 18: *Eroded Image.*

Subtracting an Image

Figure 19, shows the subtracted image. The eroded image, which is obtained in the previous step, is subtracted from the dilated image. Subtraction is required to break the outer boundary of an image. The main aim of subtraction of images is that when hole filling operation is performed on an image then it fills all the region of the plate. When subtraction of images is used then holes filling operation will not fill the desired portion of the image.

Filling Holes

The next step is filling holes. In the presented work, when Morphological operations like dilation and erosion are performed, then the image filling operation is performed on that binary image. All broken parts of an object has been presented in the image. A filling operation is performed on binary images and grayscale image. Weaken parts of an image are filled up by the image filling operation. The end of the process will take place when object boundaries reached. Figure 20 (ac) shows the holes filled image. The resultant of holes filled image contains boundary edges. This undesired region of the image is removed in the next step.

Segmenting Characters Using Bounding Box

When all preprocessing steps are applied on an image then next step is to segment the characters of an image. In this paper, character segmentation is done by using a bounding box technique. In this method, each and every object of an Image is enclosed by a bounding box [27]. In the boundary rectangle technique, an enhanced image is used. The main consideration in the bounding box technique is the connected regions. The most important thing is the identification of the connected region. In the license plate detection system, the most critical step is the segmentation. There are various techniques available, which can be used for the segmentation of an image. Such as horizontal and vertical projections, Hough transform, edge detection, AdaBoost algorithm and image binarization. The Bounding box is the most efficient technique among various techniques for segmentation of an image. In this technique, the bounding box will appear on each and every character of the image. Figure 21 shows the bounding boxes on image and Figure 22 shows the segmented characters.

Recognizing Characters of Segmenting Image

Character recognition is the final step of the ALPR. In the previous step, the segmentation of license plate is done and segmented image of the number plate is obtained. After that, character recognition is to be performed on the segmented image. Template Matching, Normalized cross-correlation and Gabor filter in recognition of character using extracted features are generally employed for the recognition process [23, 28, 29]. Kirsch Edge Detection is used for feature extraction [30, 31]. Artificial Neural Network is the most widely used technique, which is used in the recognition of characters of the segmented license plate. The next step is to recognize the segmented characters obtained in the previous step. In this paper, the ANN is used for recognition of characters. Mean Square Error used to determine the performance of the system. ANN training is necessary for the recognition of characters. ANN is trained for different fonts of similar characters. In this work, sixteen fonts of a character or digit are used for training of the ANN. Firstly, the ANN is trained then some values of trained ANN are stored in the workspace of MATLAB.

Table 1: *ANN Training Parameters.*

S. No.	Parameter Name	Value of Parameter
1.	Number of hidden layer neurons	40
2.	Training Algorithm	Levenberg-Marquardt Back-propagation (trainlm)
3.	Feature Vectors	48
4.	Number of Layers in Network	2
5.	Regression Coefficient	0.95761
6.	Data Division	Random
7.	Performance	Mean Squared Error

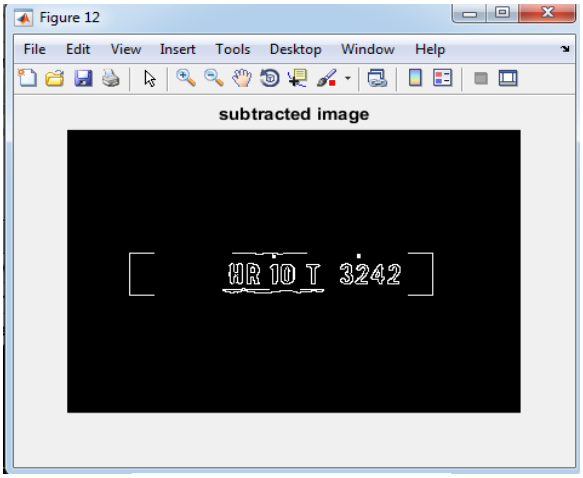

Fig. 19: *Subtracted Image.*

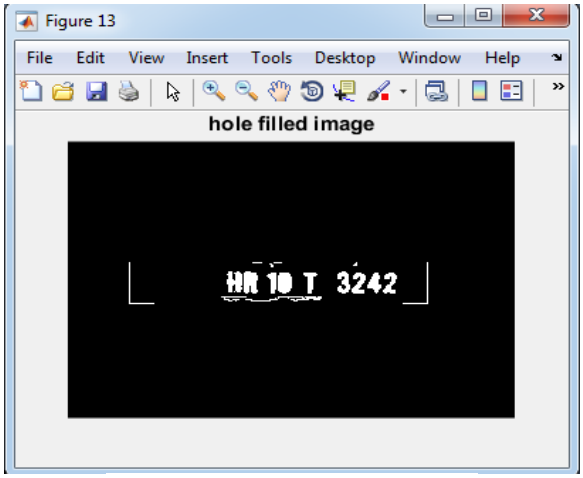

Fig. 20(a): *Holes Filled Image.*

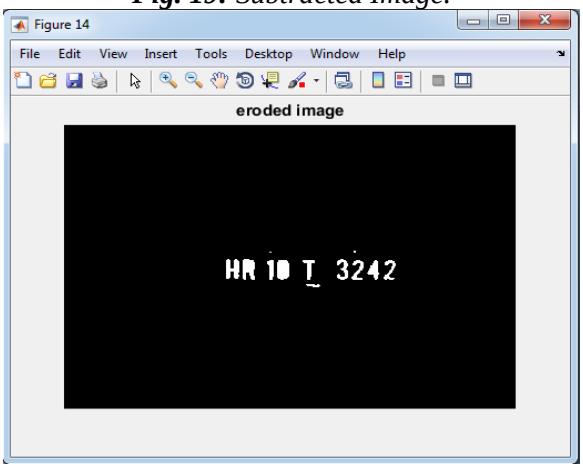

Fig. 20(b): *Video Input File Eroded region of the image.*

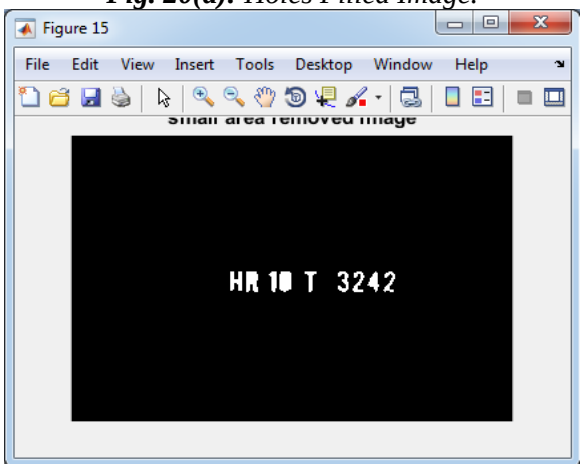

Fig. 20(c): *Small region eroded Image.*

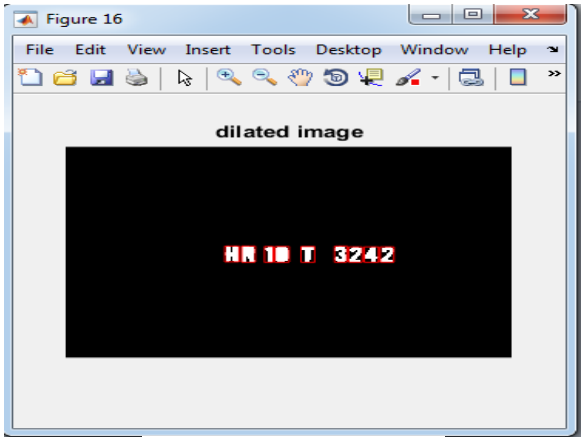

Fig. 21: *Bounding Boxes.*

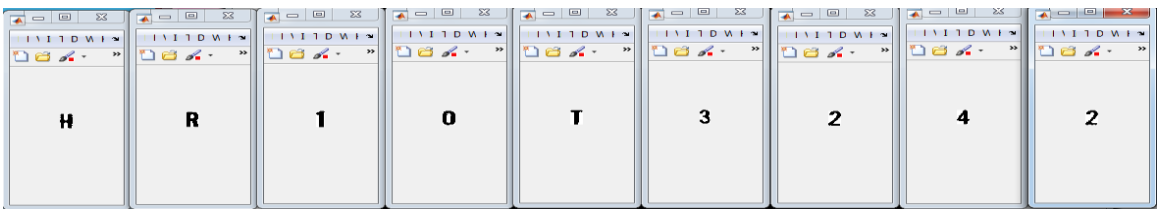

Fig. 22: *Segmented Characters.*

Fig. 23: *Different fonts used for training of neural.*

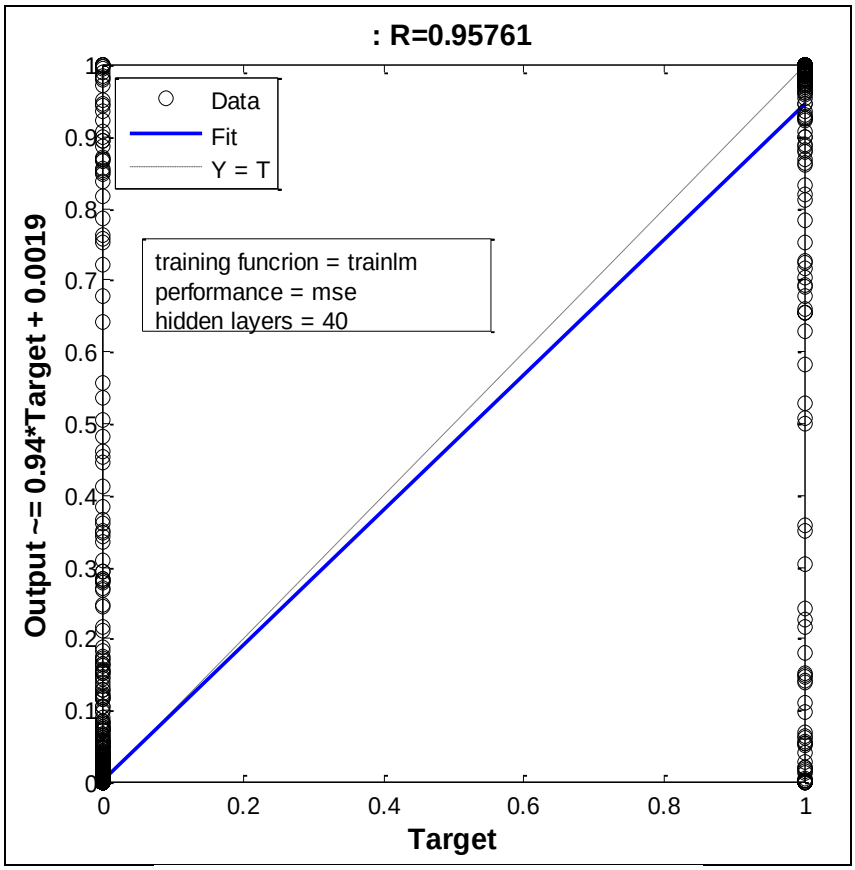

Fig. 24: *Regression Characteristics of System.*

Different fonts of characters or digits are given in Figure 23, Table 1 shows the ANN training parameters. Regression characteristics of the proposed system are shown in Figure 24. After that, extracted characters from vehicle license plate are fed into the ANN. Now, the resultant of the neural network is the license plate number of the vehicle as shown in Figure 25, Thus, the license plate of a vehicle is recognized automatically.

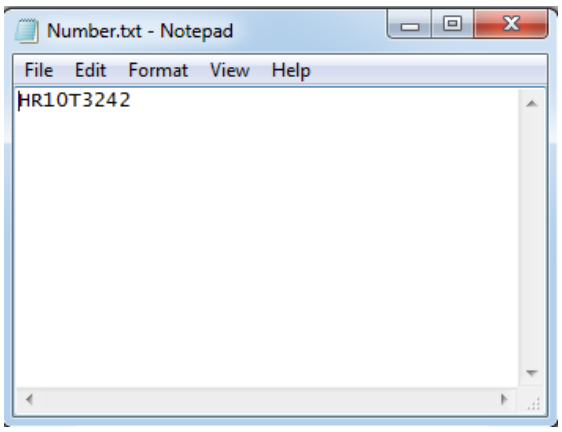

Fig. 25: *Recognized License Plate.*

CONCLUSIONS AND FUTURE DIRECTION

The ALPR system is used to recognize the vehicle number plate. Many techniques are employed for the localization, segmentation and recognition of the number plate. ANN is used in this paper for the recognition of the license plate. ANN technique helps to increase the performance of ALPR system. The influence of lighting is removed by using good preprocessing methods. The recognition is also improved, for ambiguous characters, for optical character recognition. If we are using different-2 ANN parameters during image pre-processing stage of plate localization, character segmentation and character recognition system got high accuracy, the recognition rate of the ANN is 96%. In this paper, many preprocessing techniques are implemented for automatic detection of the license plate. There are different techniques that can be used for recognition of the license plate of the vehicle. As we know, every system has some merits or demerits. Similarly, in this paper, some limitations are there. The researcher can further work on the limitations of this system. In the presented work, the video is taken as an input for the ALPR system. Due to the motion of vehicle and camera, the captured video or image is suffering from motion blur effect in the input video. So this blurring effect can be minimized by using motion blur restoration as a preprocessing step to handle such kind of problems. Unify the illumination conditions may lead to better LP localization results. It is difficult to recognize broken characters of license plates. These problems can be taken as the future research work by researchers.

REFERENCES

1. Liu G, Ma Z, Du Z, Wen C. The calculation method of road travel time based on license plate recognition technology. *Advance in Information Technology Education.* 2011; 201: 385–389p.
2. Chiou YC, Lan LW, Tseng CM, Fan CC. Optimal locations of license plate recognition to enhance the origin-destination matrix estimation. *Asian Transport Studies,* 2012; 2 (1): 1–14p.
3. Kranthi S, Pranathi K, Srisaila A. Automatic number plate recognition. *International Journal of Advancement in Technology.* 2011; 2 (3), 408–422p.
4. Kocera HE, Cevikb KK. Artificial neural networks based vehicle license plate recognition. *Procedia Computer Science.* 2011; 3, 1033–1037p.
5. Anagnostopoulos CNE, Anagnostopoulos IE, Psoroulas ID, Loumos V, Kayafas E. License plate recognition from still images and video sequences: A survey. *IEEE Transaction on Intelligent Transportation System.* 2008; 9 (3), 377–391p.
6. Sarfraz M, Ahmed MJ, Ghazi SA. Saudi Arabian license plate recognition system. *International Conference on Geometric Modeling and Graphics.* England. 2003, July 16-18. 3–41p.
7. Shrivastava V, Sharma N. Artificial neural network based optical character recognition. *Signal & Image Processing: An International Journal.* 2012; 3 (5), 73-80p.
8. Neural network basics, available at, http://en.wikibooks.org/ wiki/Artificial_ Neural_ Network/ Neural_ Network _Basics.
9. Artificial_neural_network, available at, http: //www.techopedia.com/definition/59 67/artificial-neural-etwork-ann.
10. (ANN)? - Artificial Neural Networks – Engineers Garage available at http: // www. engineers garage. com/ articles/ artificial-neural-networks
11. Artificial Neural Networks/Neural Network Basics, available at, http://en. Wikibooks. org/ wiki/ Artificial_ Neural_ Networks/ Neural_ Network_ Basics.
12. Historical background in detail available at http://www.doc.ic.ac.uk/~nd/ surprise_96/ journal/ vol4/ cs11/ report. html# Appendix A.

13. Rani S, Dahiya PK. A comprehensive study of different techniques of automatic license plate recognition system. *International Journal of Computer Applications*, 2015; 121 (17): 1-9p.
14. Dedgaonkar SG, Chandavale AA, Sapkal AM. Survey of methods for character recognition. *International Journal of Engineering and Innovative Technology (IJEIT)*, 2012; 1 (5): 180-189p.
15. Demuth H, Beale M. *Neural Network Toolbox*. User's Guide, Version 4, Mathworks.
16. Miyamoto K, Nagano K, Tamagawa M, Fujita I, Yamamoto M. Vehicle license-plate recognition by image analysis. *International conference on Industrial electronics, control and instrumentation*. Japan. 1991, October 28-November 1. 1734–1738p.
17. Kanayama K, Fujikawa Y, Fujimoto K, Horino M. Development of vehicle-license number recognition system using real-time image processing and its application to travel-time measurement. *IEEE Vehicular Technology Conf*erence. USA. 1999, May 19-22. 798–804p.
18. Lee ER, Kim PK, Kim HJ. Automatic recognition of a car license plate using color image processing. *International Conference on Image Processing*. USA. 1994, November 13-16. 301–305p.
19. Comelli P, Ferragina P, Granieri MN, Stabile F. Optical recognition of motor vehicle license plates. *IEEE Transaction on Vehicular Technology*. 1995; 44 (4): 790–799p.
20. Rahman CA, Badawy W, Radmanesh A. A real time vehicle's license plate recognition system. *IEEE Conference on Advanced Video Signal Based Surveillance*. USA. 2003, July 22. 163–166p.
21. Tang S, Li W. Number and letter character recognition of vehicle license plate based on edge Hausdorff distance. *International Conference on Parallel Distributed Computing Application Technologies.* China. 2005, December 5-8. 850–852p.
22. Ozbay Y, Karlik B. A fast training back propagation algorithm on windows. *3rd International Symposium on Mathematical & Computational Applications, September*, Turkey, 2002, September. 204-210p.
23. Kim MK, Kwon YB. Recognition of gray character using Gabor filters. *5th International Conference on Information Fusion*. USA. 2002, July 8-11. 419–424p.
24. Bishop CM. *Neural networks for pattern recognition*. UK: Clarendon press, Oxford; 1995.
25. Saini MK, Saini S. Multiwavelet transform based license plate detection. *Journal of Visual Communication & Image Representation*. 2017; 44: 128-138p.
26. Saini MK, Saini S. Analysis of License Plate using MWT. *International Conference on Innovations in Information, Embedded and Communication System. Coimbatore*, India. 2017, March 17-18. 332-337p.
27. Bounding Box, available at, http: //en. wikipedia. org/ wiki /Minimum_bounding_box.
28. Gao Q, Wang X, Xie G. License plate recognition based on prior knowledge. *International Conference on Automation Logistics.* China. 2007 Aug 18-21., 2964–2968p.
29. Ling X, Lu X, Huang W. Vehicle license plate character recognition. *International Conference on Neural Netork & Signal Processing.* China. 2003, Dec 14-17. 1066–1069p.
30. Abdullah SNHS, Khalid M, Yusof R, Omar K. Comparison of feature extractors in license plate recognition. *Asian International Conference on Modeling Simulation.* Thailand.2007. 502–506p.
31. Abdullah SNHS, Khalid M, Yusof R, Omar K. License plate recognition using multicluster and multilayer neural networks. *2nd International Conference Information and Communication Technologies*. Syria. 2006, April 24-28. 1818–1823p.

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