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# Pattern Recognition in Digital Images using Multiclass SVM and Back Propagation Neural Network - A Comparative Study

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**ABSTRACT**

In this paper, the authors proposed a novel method for character extraction and recognition from Vehicle number plate images. Initially pre-processing operation was performed to remove any noise in the image. The Characters found in the image are made clear through proper localization with the help of novel Morphology based Compound operations. The compound operation involves dilation, erosion and subtraction of the filtered image. Certain operations were repeated to attain an eminent binary morphological image. After the extraction process, the image was fed into the back propagation neural network for recognition. The selectivity, sensitivity and the accuracy rate was computed to show the performance of the network. Matlab 7 coding is used for implementation. 75 different images were subjected to the proposed method. The recognition accuracy of the proposed method is compared with the existing work.

## INTRODUCTION

Machine replication of human functions is an ancient dream. Over the past five decades machine reading has grown from dream to reality. Among them optical character recognition has become one of the most successful application in the field of pattern recognition and artificial intelligence. Many systems performing OCR exist today for a variety of applications, although the machines were still not able to compete with human reading capabilities. The usual and traditional way of entering data into a computer was through keyboard. In certain cases automatic identification may be the need. Various technologies for automatic identification exist and they cover the needs of application under different area. License Plate Recognition is an image-processing technology that was used to identify vehicles by their license plates. It is used in various security and traffic applications, such as the access-control system, etc.

Automatic number plate recognition was invented in 1976 at the police scientific development branch in UK (Phalgun pandya and Mandeep singh., 2011). Its main focus is to extract the plate image and then recognize the characters from it. Extraction of characters from vehicle number plate is one of the major application areas of pattern recognition, which has its widespread use in day to day life. Most of the techniques that are used for character recognition in literature have their own merits and demerits. There are different combinations of operations for the extraction of characters from vehicle number plates. They are number plate localization, Normalization, character segmentation and extraction. The combinations of these techniques are based on an in-depth examination of how to use a combination of algorithms at different stages. It is this combination province. In this paper, our focus is on the recognition of characters from vehicle number plate and hence much effort is not posed on the rules or the style of the number plates from different countries.

Different techniques that are employed for character recognition involves template matching, statistical techniques, structural techniques and neural network. In the case of character recognition, statistical and



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structural feature based methods gain more importance. These techniques can be used either individually or in a hybrid form to improve the recognition accuracy. Neural network comes under

The category of structural approach. The most widely used neural network for character recognition is the multilayer feedforward back propagation neural network. SVM (Support Vector Machine) normally comes under statistical learning category.

The Backpropagation neural network (P.Pandi Selvi, Dr.T.Meyyappan, 2013) is used for training and recognition. The network is initially trained with desired set of characters, and then sample number plate datasets are provided for recognition. The network here consists of three layers, the input layer, hidden layer and the output layer. On application of a set of inputs, through the input layer, it passes through the hidden layer and then to the output layer, and for each layer weight value is calculated. The network then produces the output, along the output layer. The obtained output is then compared with the desired output. The calculated error value is then propagated backwards through the network, and the weight values are adjusted for each corresponding layer in the network, which is mainly to reduce the error value, and the output is calculated again. The entire process continues until the error value drops behind the pre-determined threshold. The network structure used is as follows.

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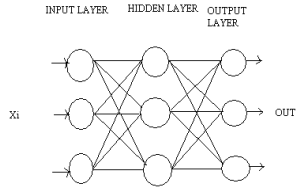


**Fig . 1:** The Network structure.

***Literature Review:***

A.Albiol *et al*. (2011), presented an approach for the detection of parked vehicles using spatiotemporal maps. C.N.K. Babu *et al*. (2008), presented a new method for the localization of license plate using morphology based approach. Preprocessing of the image was carried out by using morphological operations. The edges in the image were retrieved for the extraction of the object features using various morphological approaches. Recognition of the contents of the plate was carried out using cross correlation followed by neural network. Their experiments were conducted with a large set of car images, which provided encouraging results.

Bharat Bhushan *et al*, (2013), proposed a license plate recognition system using neural networks and multithresholding technique. Their proposed method can be used for both color as well as gray scale images. Cemil Oz, Rasit Koker, proposed a vehicle license plate recognition using artificial neural networks. With their approach they obtained better recognition rate and hence they can be used in various real time applications by including certain factors.

Dhiraj ahuja *et al*, (2013), proposed a license plate recognition using wavelets and neural networks. In this paper different wavelet shape features of license plate characters are extracted and the analysis of wavelets is done on the basis of recognition rate and time. Haar wavelet requires least time for license plate detection, character segmentation and feature extraction. As the number of license plate images in training database is increased recognition rate is increased and the training time is also increased.

F.Faradji *et al*, (2007), presented a morphology based approach for license plate location. In the first stage of their work, they extracted vertical edges of the input image using Sobel mask. In the second stage histogram analysis was used for finding the candidate regions and they were verified by using defined compact factor. In the third stage license plate image was located with the help of morphological operators. They have used a total of 400 images and their algorithm was able to achieve an accuracy of 83.50%.

Harpreet Kaur, Naresh kumar Garg, (2014), proposed a number plate recognition using neural network classifier and K-Means. Their work focuses mainly on feature extraction and recognition. Their work is done on the stationary vehicles with white background. In the near future They were trying to implement on moving vehicles, colored background of number plate and the recognition can be performed on darker number plate.

Ioannis Giannoukos *et al*, (2010), proposed an operator context scanning to support high segmentation rate for real time license plate recognition. Their approach was tested on images of various resolutions under different environmental conditions. Jianbin Jiao *et al*, (2009), proposed a configurable method for multi-style License Plate recognition by representing the styles with quantitative parameters. The experimental results proved the effectiveness of the algorithm and works faster.

Jinn-Li Tan *et al*, (2013), introduced the idea of edge-geometrical features using morphological approach to locate the license plate. Their method was based on gray scale images. A total of 350 plates were captured with different background, angle, distance and illumination. Among them 250 images were taken during day time and the others during night time. Further they were trying to segment and recognize the characters.

Jon Arrospide *et al*. (2014), made a study of feature combination for vehicle detection based on Image processing. They focused on the classification of surrounding vehicles through image analysis. They found that although various techniques exist, they were in lack of certain aspects. First, comparison between some methods using a common body of work was not addressed. Secondly, popular features for vehicle classification was not considered and reported. Hence these combination of techniques need to be explored and to present a new method for the better fusion of classifiers. Their study showed that fusion of classifiers and techniques prove to be highly beneficial for vehicle verification.

P.Kulkarni *et al*, (2009), presented a feature based approach for the localization of Indian number plates. Their problem domain focused on various parameters like, size of the number plate and characters, location of number plate, type of font used, background and foreground color, etc. With their approach, they were able to locate the number plate under varying illumination conditions. They achieved a success rate of 87%.

Kumar Parasuraman, (2010), proposed a new concept of using SVM for license plate recognition systems. They proposed an algorithm for the segmentation and recognition of characters. For the recognition of characters they used SVM. The recognition result is obtained by finding the maximum value between the outputs of SVMs. Their results have shown that the method is best suitable even for poor quality images.

Lokesh Selvaraj *et al*, (2014), suggested a novel speech recognition method based on improved particle swarm optimization and vector quantization. Their technique achieved 97.14% accuracy.

Mohammad S.Khorsheed, (2015), presented a novel method for recognizing cursive typewritten text using segmentation-Free system. They extracted simple statistical features from a one-pixel wide window which was sliding across the text line. The feature set was then clustered in the feature space using vector quantization. The algorithm proposed by them was segmentation-free and it uses run-length encoding. This feature vector sequence was then injected to a classification engine for training and recognition purpose. The recognition system was then applied to a data corpus which includes cursive Arabic texts of more than 600 A4-size sheets typed in multiple computer-generated fonts. The algorithms implemented VQ to map continuous density vectors to discrete simple symbols. Each of the incoming feature vectors was then matched with each cluster and then assigned the index relevant to the cluster having minimum difference value. The recognition engine was based on the Hidden Markov model. A comparison was then carried out at the end with another algorithm that extracted intensity features. With this approach the author proved that the approach improved the overall system performance.

Phalgun pandya and Mandeep singh. (2011), proposed a morphology based approach to recognize number plates in India. In this paper, the authors proposed an efficient morphology based opening and closing operations for the localization of Indian vehicle number plates. Skew correction is done for the better segmentation of characters, since it affects the accuracy of character recognition. Character extraction approach is based on template matching. The various steps in their work are as follows, Binarization: in this stage the input image is filtered using median filter and the difference image is closed and opened using 5*5 size structuring element. The resultant image is binarized using global threshold value. The next step is the region filtering stage. In this stage, using region based filtration technique, they removed non-candidate regions. The number plate regions that were extracted are fragmented into parts and these information's are merged to localize the plate. The next step is the verification of localized candidates: here the false number locations are discarded with the help of character count. The number of characters in the finalized number plate area was calculated. Finally all the unwanted data are removed. The next step is the number plate extraction and verification: the extracted sub-image then passes to the character recognition module. Scaling and rotation operations were also performed on the extracted image to locate the number plate. The characters in the number plate were then segmented which then undergoes the template matching process. The characters which were extracted are verified on the basis of certain rules followed in the country, and are then displayed. Their proposed algorithm provides up to 90% accuracy.

Pranay Meshram *et al*, (2014), proposed an automated license plate recognition system using regular expression. In their work they used blob detection method for detecting number plate of vehicle. The recognized character is then searched for standard format using regular expression. Future application of it refers to building various intelligent dash boards for cars, etc.

Shouyuan Yu *et al*, (2015), proposed a novel method for license plate location using wavelet transform and EMD analysis. Their experiment proved that they were able to locate the license plate with a high accuracy of 97.91% in a short period of time.

## MATERIALS AND METHODS

This research work proposes a comparative study of Multiclass SVM and the Back propagation neural network for the extraction and recognition of characters from vehicle number plate. License Plate Recognition is a challenging problem with machine vision and automation. Many researchers have been carried out but none of them provided an efficient low cost solution. Most of the works proposed in the literature use neural networks for the recognition of dimensions, font, lighting and other features. The main reason for focusing in number plate recognition is that, it helps to detect, deter and disrupt criminality at local places. The primary focus of the work is the extraction and recognition of characters from vehicle number plate.

Various algorithms and methods were developed by eminent researchers all over the world. But still there exists certain difficulties that the software needs to cope with. Hence, in order to overcome these pitfalls and to improve the recognition accuracy of characters, the authors introduced a new combination of techniques. The proposed work proceeds by thorough analysis of recognition problem and every step and specified what technique to use, to overcome the pitfall in an organized manner.

In this paper the following research work have been carried out.

(i) Recognition of characters from the number plate using a multiclass SVM containing 36 classes.

In most of the research papers, it is evident that the authors use only two classes for classification when using SVM classifier. Only very few research work uses Multiclass SVM and that too having very few classes. Hence in a motive to include much number of classes to improve the recognition accuracy, SVM classifier containing 36 classes was constructed.

The number plate containing 6 characters was considered for the experiments. Vehicle number plate images in RGB format were chosen. RGB image is first converted to gray scale image for further processing. The steps in the proposed method are outlined below:

i.)Reading the RGB image.
ii.)Conversion to Grayscale image.
iii.)Denoising with Median filter.
iv.)Extraction of characters with compound morphological operations Erosion, Dilation and Subtraction.
v.)Recognition of extracted characters with Back propagation neural network.

A license plate recognition using wavelets and neural networks. In this paper different wavelet shape features of license plate characters are extracted and the analysis of wavelets is done on the basis of recognition rate and time. Haar wavelet requires least time for license plate detection, character segmentation and feature extraction. As the number of license plate images in training database is increased recognition rate is increased and the training time is also increased. F.Faradji *et al*, (2007), presented a morphology based approach for license plate location. In the first stage of their work, they extracted vertical edges of the input image using Sobel mask. In the second stage histogram analysis was used for finding the candidate regions and they were verified by using defined compact factor. In the third stage license plate image was located with the help of morphological operators. They have used a total of 400 images and their algorithm was able to achieve an accuracy of 83.50%.

The recognized character is then searched for standard format using regular expression. Future application of it refers to building various intelligent dash boards for cars, etc.

### *A. Computational Procedure for the Proposed Method:*

Step 1: Read the RGB image f.
Step 2 : Convert f to grayscale image g.
g=rgb2gray(f)
Step 3: Apply Median Filter to denoise f
$g(x,y) = \text{median}\{g,(s,t)\}(s,t) \in S_{xy}$ where $S_{xy}$ represent the set of coordinates centered at the point (x,y).
Step 4: Perform Morphological Compound operations using disk shaped structuring element. A disk shaped structuring element is first chosen, by the following matlab code, se=strel('disk',1);
$g(x,y) = f(x,y) \oplus S$; g(x,y)= { 1 if S fits f(x,y) 0 Otherwise} (Dilation)
$g(x,y) = f(x,y) \ominus S$; g(x,y) ={ 1 if S hits f(x,y) 0 Otherwise} (Erosion)
E= g(x,y)-g (Image subtraction)

$(f * g)(t) = \int^{t}_{0} f(T)\, g(t- T)dT$ for f, g : [0,∞)->R(Convolution)
$Q(i,j)=P_1 (i,j) \times C$
$g(x,y) = f(x,y)\Theta S$; g(x,y) ={ 1 if S hits f(x,y) 0 Otherwise} (Erosion)
E= g(x,y)-g (Image subtraction)
$X_k = (X_{k-1} \oplus B) \cap A^C$ *K=1,2,3,…* (Filling the regions of the image)
H=bwmorph(F,'thin',1);
$g(x,y) = f(x,y)\Theta S$; g(x,y) ={ 1 if S hits f(x,y) 0 Otherwise

***Comparative Analysis:***

The proposed method is experimented with number plate images of vehicles in Karachi. The performance metrics of the proposed method is compared with existing methods (P.Pandi selvi and T.Meyyappan, 2015). Although the morphological operations used in this work are the general one, their usage at various stages yields better results. The proposed work achieves better recognition rate. The proposed work does not include segmentation process.

Most of the contributions made earlier achieved an accuracy 83.50% by (F.Faradji, A.H. Rezaie, M.Ziaratban, 2007), 90% by Phalgun Pandya, Mandeep Singh, 97% by (P.Pandi selvi and T.Meyyappan, 2015). The proposed method was compared with the aforesaid techniques.

Most of the research work that have been carried out focus on the improvement of accuracy in extracting and recognizing the characters from the vehicle number plate.

In the proposed method, the recognition process was carried out with Back propagation neural network. The method achieves a recognition accuracy of 91%. The sensitivity and selectivity graphs are also shown in figure 13. The achieved accuracy rate was higher than the methods proposed by F.Faradji et. al, (2007) 90% by Phalgun Pandya et.al, but lesser than P.Pandi selvi et. al.(2015).

## RESULTS AND DISCUSSION

The experimental results of the proposed method is given this section.

Step 1: The given image as shown in figure 2 is read and resized. The aspect ratio is maintained.


**Fig. 2:** Input image.

Step 2: In the preprocessing step, the noise present in the image is removed with the help of median filter and the resulting image is as shown in figure 3.


**Fig. 3:** Image after removing noise.

Step 3: Compound Morphological operations:

Figure 4 shows the image after dilation operation.


**Fig. 4:** shows the image after erosion operation.


**Fig. 5:** Eroded image.

Figure 6 shows the image with enhanced edges after subtraction operation.


**Fig. 6:** Edge enhanced image.

Figure 7 shows the brightened image after convolution and erosion.


**Fig. 7:** Eroded and convoluted image.

Figure 8 shows the image after the removal of unwanted horizontal lines.


**Fig. 8:** Eroded image after eliminating horizontal lines.

Figure 9 shows the image after filling operation.


**Fig. 9:** Filled Image.

Figure 10 shows final morphological image.


**Fig. 10:** Binary morphological image.

The characters obtained from the above stage are displayed and stored in a file, as shown in figure 11.


**Fig. 11:** The extracted characters.

The extracted image undergoes the classification process. The above illustration was given for a single image; the method was tested with 75 number plate images. Recognition rates of those images are measured and tabulated.

For recognition with Back propagation, neural network sensitivity and selectivity metrics are also taken into consideration. The extracted characters are fed into the trained neural network for recognition. The recognized image is shown in figure 12.

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**Fig. 12:** The recognized characters in the image.

The sensitivity and selectivity graph based on true positive and false positive cases is shown in Fig 13.

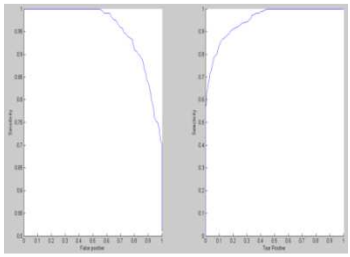

**Fig. 13:** The sensitivity and selectivity graph.

From the analysis it is evident that the recognition accuracy with template matching approach was 90% and morphology based approach was 83.5%. Back propagation neural network approach achieves the recognition accurcy upto 91%. With Multiclass SVM classifier the recognition accuracy was upto 97%. Recognition accuracy with Backpropagation neural network can be improved further with optimized weights in network layers.

***Conclusion:***

Various other methods proposed by researchers have their own limitations which are overcome in the proposed method. Back Propagation approach gives better recognition accuracy upto 91%. It gives better results compared to existing methods in the literature. Performance of the SVM classifier gives recognition accuracy upto 97% and is better than Back Propagation Neural Network approach. Future research work should focus on improving the performance of BPNN approach with optimized weights in layers.

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