Automatic License Plate Recognition Technique using Convolutional Neural Network

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ABSTRACT
This research work purposes an automated system for recognizing license plate technique using Convolutional Neural Network. On Indian roads there are variety of number plate format and variety of fonts are used in vehicles and the most common vehicle number plate used yellow or white as background and black used as foreground color. The proposed model can be partitioned into four parts-1) Digitization of image 2) character segmentation 3) Padding and Resize 4) Character Recognition. Here, Character Segmentation is done using connected component analysis. After that convolutional neural Network is used for recognition of characters. In the proposed system, Character segmentation and resize and padding of the image is done using MATLAB and Character Recognition part is done using PYTHON. The performance of the proposed algorithm has been tested on real car images. The proposed system is mainly applicable to West Bengal cars' license plates. Experimental verification is done using a dataset of 45 images in different environmental conditions.

General Terms
Image processing, convolutional neural network.

Keywords
Number Plate recognition, character segmentation, convolutional neural network, character recognition.

1. INTRODUCTION
Number Plate Recognition is a mass surveillance method which is used to identify the vehicle. Since every vehicle have a unique number plate so if we need to recognize a particular vehicle we can use the License Plate. So Automatic Number Plate Recognition (ANPR) is an image processing technique which is use to recognize a vehicle without human intervention directly. Using this, user can track, identify the vehicles automatically. To read the license plate character, the system uses "Optical Character Recognition" method. For vehicle surveillance, Automatic Number Plate recognition plays a very important role in the last few years because of the unlimited increase of the car which make it difficult to manage and monitor by human. This system captures the image of the vehicles and extract the number form the image automatically. We can use this system in many purposes like automatic toll tax collection, traffic safety, car park system etc. There are total five steps in ANPR algorithm:

a) Vehicle image capture
b) Image preprocessing
c) Number plate detection
d) Character Segmentation
e) Character Recognition

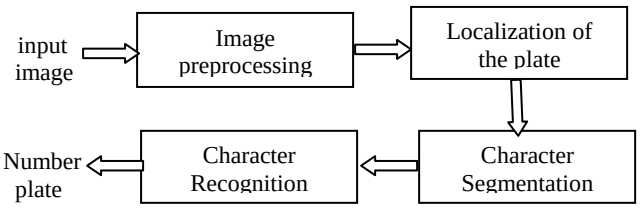

Fig. 1: Schematic diagram of ANPR.

The system needs a camera to capture the image, generally it uses infrared to capture the image at any time of the day. Then it finds the location of the number plate in the image

Fig. 2: Image of number plate

After detection and extraction of the number plate, the plate must be separated from the background images. It increases the processing speed of the system. Third step is Character Segmentation to get individual character and last step is Character Rec-ognition to recognize each individual characters which we get from Segmentation process which give the result as the plate number.

2. RELATED WORK
During last couple of decades different techniques and methods have been proposed for efficient recognition of plate characters. Some of the related work are as follows : An upgraded recognition method of license plates based on Genetic Neural Network is presented in [1].Here the authors propose the Genetic Algorithm(GA) to the weights training process of Back Propagation(BP) network and build up a new neural Genetic Algorithm BP(GABP).Genetic Algorithm is a global optimization search algorithm, which depends on natural selection and genetic theory. Artificial Neural Network (ANN) is an interdisciplinary method of biology and computer science, used in signal processing, pattern recognition. The author build up the new network GABP by integrating the advantages of global searching of GA and the instructive searching of BPNN.GA is used to develop the weights and threshold of the network, which should persuade it get into the neighborhood of global optimal solution. Then the Gradient method is used to train the eights until the network assembles to the global optimal solution. Then in order to improve the convergence precision, the gradient method was used to train the network and find the global optimal or second best solution with better performance. In this technique, feature extraction is also important for developing the recognition rate of the network. The proposed

method saves the time of training network and obtain a highly recognition rate.

In [2] a highly reliable license plate detection and recognition approach using mathematical morphology and support vector machines (SVM) has been proposed. There are three main steps in this approach, 1) License plate detection 2) Segmentation 3) Recognition. At first the RGB image is converted to Gray-scale image. To extract the License plate form the image, contrast enhancement is used. Sobel operator is used to trace out all the edges form the image. After that closing operation is used between two consecutive characters on the License Plate. This operation is used to fill the whole plate region. To remove all the objects that are smaller than LP, an erode operation is used. The author uses 8 connected component algorithm for segmentation purposes and different numbers are labelled. For better performance, each character are cropped and processed separately. After that the gray image is converted into binary image. Global approach and Local approach are used for thresholding purposes. In case of Global approach, one threshold value is applied for each pixel, but in case of Local approach, using windowing, each image is sub-divided into sub-images and then histogram is used for calculating the threshold value. For better performance adaptive threshold is used. Then area opening and erosion is used for removing the undesired part from the License plate. After that SVM is used in the last stage to make a classifier to categorize the input numbers of the license plate into one of 9 classes. After extracting the characters from segmentation step, characters are resized and feature vector is formed.

In [3] Maximally Stable Extremal Region (MSER) is used for license plate recognition. For preprocessing the image gray-scaling and gray stretching is used. For reducing the regional edge intensity and low edge intensity regions in the whole image, Gray-scale transformation is used and Gray stretching is used for removing the interference regions. By using appropriate parameters, MSER are extracted from the image. After that some morphological operations are used for removing the noise from the image. Gray level jump and horizontal projection are used for determining the lower and upper borders of the license plate and left and right borders are determined by vertical projection.

In [4] character Segmentation is done using vertical projection method. The horizontal projection calculation, horizontal frame of license plate removal, vertical projection calculation and fining the edge of character all are under Segmentation process. Before applying the vertical projection to find the top and bottom edge of license plate character, all interferences are removed from the license plate. Then using the horizontal projection, top and bottom edge of the license plate are found. The vertical projection is used to analyze the intensity change pattern of the plate region. After this operation, the 2D image information is turned into sum of 1D row pixels. After determining the row of character boundary, left and right boundaries are found. Finally, normalized method is used and then to recognize the characters, templates matching or neural network methods are used.

For the extraction of positioning in license plate recognition system, the authors propose a new algorithm which is based on improved Robert's edge detection and morphology in [5]. In traditional Robert operation, to find the edge operator, Robert's operator has been used. Robert operator, 2*2 operator template, is a Partial differential operator. In improved Roberts algorithm, the original image is converted into gray-scale image. Then to reduce the false fringes, mean filtering is done with the help of selected template with a size 3*3. In the next step, image binarization is done using threshold Selection. To divide the image into target and background, a threshold value is computed.

3. PROPOSED METHODOLOGY

The proposed method consists of several steps to identify different vehicle number plate. The steps are: '

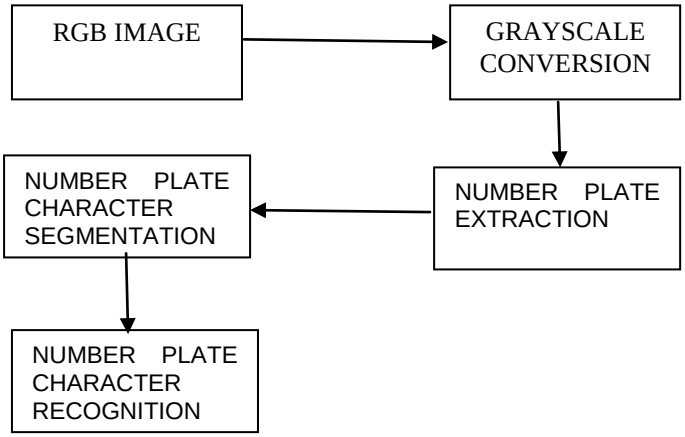

Fig 3: Process Flow Diagram of Proposed Method

3.1 Image Acquisition

At first the image has been captured using a mobile camera or digital camera and then connected to the PC. The images are in RGB format and then it processed for the number plate extraction. Then we need to resize the image keeping the aspect ratio same.

3.2 2.2 Gray-Scale Conversion:

Here, the RGB image is converted into Gray-scale image. The color image consists of three colors, Red(R),Green(G) and Blue(B) each consuming 8bits of information (i.e total 24-bit).WE need to convert this 24-bit color image into 8-bit gray image using the formula written in equation(1).The Gray-scale transformation facilitates the plate extraction and increases the processing speed.

$$g=0.299R+.587G+0.114B.....(1)$$

3.3 2.3 Image Binarization:

We need to convert the gray scale image into binary (White and Black) image using a suitable threshold value for better output. So the resulting image consists only black and white pixels.to establish the uniformity in the dimensions of the input, the variable size image gets transformed into a binary matrix of fixed pre-determined dimensions, leading to reduce computational time.

3.4 Character Segmentation:

After plate extraction, the next step is to isolate each characters from the image component. This step is called Character Segmentation. For this purpose Connected Component labelling (CCL) is used by which each characters are labelled uniquely and identify them in the next step. The CCA scans and labels the pixels of a binarized image component and every pixel is assigned with a value depending on the components. After that the connected components are analysed and remove the long and wide components and only left the components depends on the defined value. After this operation we get a set of foreground

segments which are supposed to be characters and digits within the license plate.

Fig 4: Segmentation of each alphanumeric characters.

3.5 Character Recognition:

After character segmentation, the next step is to recognize each character in the number plate. In the proposed system, the character recognition is done by Convolutional Neural Network.

3.6 Convolutional Neural Network:

A Convolutional Neural Network (CNN) formed by one or more convolutional layers and then followed by one or more fully connected layers. There are four main operation in convolutional Neural Network.

1. Convolution
2. Non-linearity(RELUs)
3. Pooling or Sub sampling
4. Classification(Fully Connected Layer)

3.7 Convolution:

The word Convolutional neural network(ConvNets) comes from "convolution operator". It is a linear operation. Extraction of the features from the input image is the main purpose of the convolution in case of ConvNets. It shows the spatial relationship between pixels by learning image features using a small squares of input data. Consider a m*n image whose pixel values are 0 and 1 and another matrix p*q. now we need to slide the p*q matrix over the m*n image and for every position we need to compute the element wise multiplication and to get the final output we need to add the multiplication output which forms the single element of the output matrix. Here p*q matrix is called 'kernel' or 'feature detector' and the final output matrix is called 'convolved feature' or the 'Feature Map'.

3.8 Non-Linearity (ReLU):

Rectified Linear Unit (ReLU) is a non-linear operation. After every convolution operation, we need to use another additional operation called ReLU. ReLU is applied to each and every pixel and replaces all the negative pixel value in the feature map by zero.That is the main purpose of ReLU. After this operation, the input Feature Map is converted into Rectified Feature Map.

3.9 Pooling:

After the ReLU operation, the next step of ConvNet is "Pooling". Pooling makes the input feature dimension smaller and more manageable but retains the most useful information. It controls over fitting that means it reduces the number of parameters and computations in the network. There are different types of pooling: Max, Average, Sum.

3.10 Fully Connected Layer:

The term "Fully Connected" defines that every neuron in previous layer is fully connected with every neuron on the next layer. It uses softmax activation function in the output layer. From the Convolution and polling layer, we get high level feature of the input image. For classifying the input image into various classes we need to use the fully connected layer.

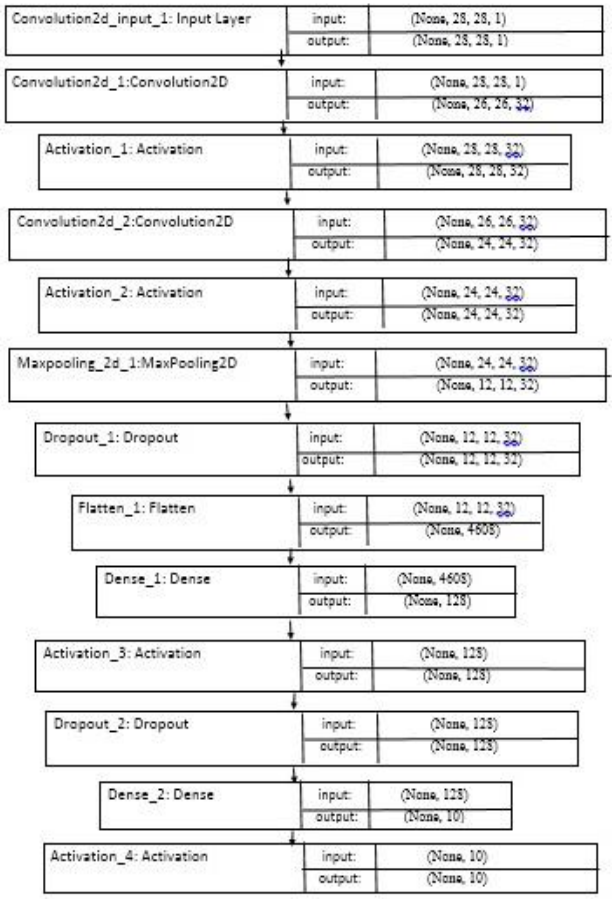

Fig 5: Basic model for convolutional neural network

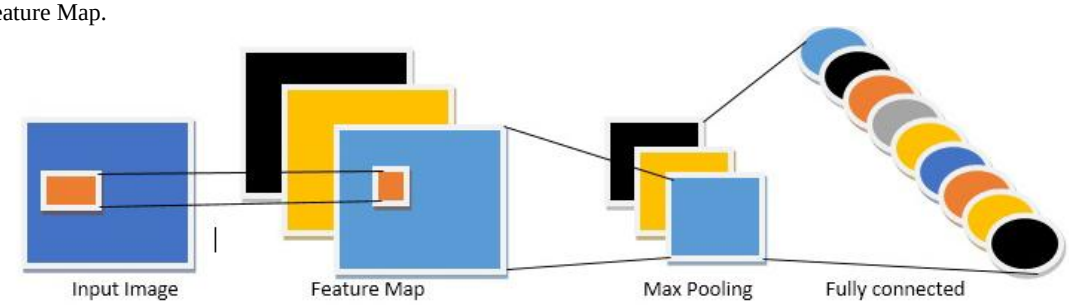

Fig 6: Basic Steps Of Convolutional Neural Network

4. EXPERIMENTS AND RESULTS

Experiments have been performed to evaluate the efficiency of the proposed system and to measure the accuracy of the system. In the experiments, 45 color images are used. Most of the vehicle number plates consists of 9 or 10 characters. All the images are captured by the mobile camera. All the images are taken under various illumination conditions. The execution time and accuracy rate were found quite satisfactory than the existing system.

Fig 7: The Dataset of the Testing images:

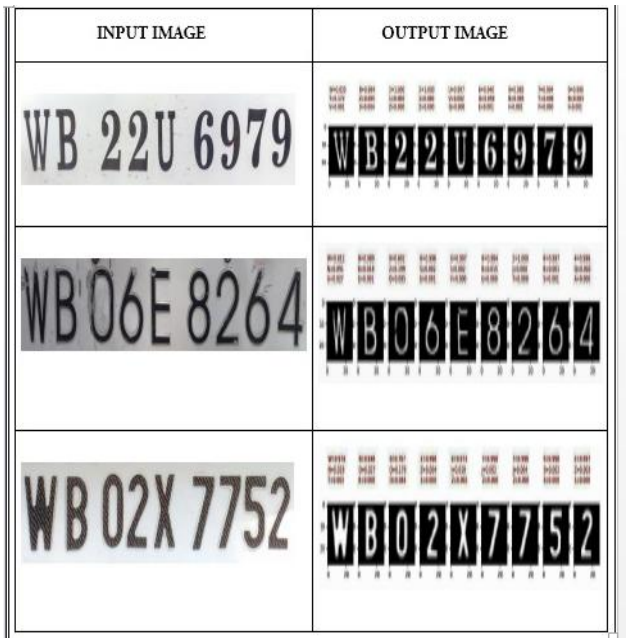

Fig 8: Experimental result

5. ANALYSIS

After the experiment, it is shown that Automatic License Plate Recognition using Convolutional Neural Network gives better result than using template matching technique. So overall accuracy for the proposed approach is 85.83%.

APPROACHES	No. OF IMAGES	ACCURACY
License Plate Recognition using Template Matching Technique	555	65.25%
License Plate Recognition using Convolutional Neural Network	555	85.83%

Fig 9: Accuracy of the two Approaches

From the above table it can be shown that the proposed system is far better than the existing system in terms of recognition accuracy.

6. CONCLUSION AND FUTURE SCOPE

In this thesis work, we have present an efficient and convenient method for recognizing license plate based on Convolutional neural network. This proposed method is designed only for Indian car number plate. Its performance is tested on 45 samples of extracted license plate image with different background, different atmospheric conditions, The simulation result shows that the system easily detect and recognize the number plate compare to existing system.

The system can be further extended to recognize number plates of other countries. For some license plate with more serious defect or the image under poor illumination, the results for the license plate extraction is not very satisfactory, which deserve us for further study. How to reduce the illumination and reflection effects can be carried out to improve the accuracy rate of this project.

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