# AN AUTOMATED SYSTEM FOR DETECTION AND RECOGNITION OF VEHICLES NUMBER PLATE BY USING ARTIFICIAL NEURAL NETWORKS

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**Abstract - Number plate detection system is a challenging problem in the field of machine vision and automation with various applications including automated hands free toll collection, border crossings, effective traffic monitoring, parking allocation management, automated vehicle access in secure establishments etc. The complexity of an automated number plate recognition work varies throughout the world. Automated Number Plate Recognition (ANPR) system is an easy to detect and recognize for the standard number plates. But in India the task of detecting and recognizing the number plate becomes difficult due to variation in number plate model and their size, the font size, font style and different languages used. Because of this, character recognition part is also very difficult. Hence, this paper proposed an improved ANPR system for all types of Indian number plates (NP), which consists of three modules: number plate detection, characters segmentation and characters recognition. In the detection module, we have combined pre-processing, mathematical morphology, thresholding, feature extraction methods to locate exact number plate region. In the characters segmentation module, we have used bounding box technique to segment characters. In the characters recognition module, we have used a Multilayer Perception (MLP) neural network and Radial Basis Function Network (RBFN) to recognize characters & numbers of Indian number Plates. We have implemented our ANPR system on 120 Indian vehicle images with different conditions such as different font size and font style, illumination, colors, reflected light, occluded plates, and Kannada Number plates. Our method is more effective than some existing methods and accuracy is improved and very satisfied for all types of Indian Number Plates.**

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**Keywords: ANPR, ANN, MLP, RBFN**

## I. INTRODUCTION

Automatic Number Plate Recognition (ANPR) system is an important technique used in intelligent transport System (ITS), which provides services to different modes of Transport and traffic management. ANPR system is an advanced machine vision technology used to identify vehicles by their number plates without direct human intervention. It is a challenging problem in the field of machine vision and automation with various applications such as parking lot ticketing system, automated hands free toll collection, automated vehicle access in secure establishments, law enforcement, border security and custom security etc. The whole ANPR system is generally framed into 3 steps: 1. Number Plate Detection, 2. Character Segmentation and 3. Character Recognition.

In the Number plate detection work, many techniques have been proposed such as: statistical analysis of Discrete Fourier Transform (DFT) of the plate signal [1], global edge features and haar like features [2], wavelet transform and EMD (Empirical Mode Decomposition) analysis [3], region and edge based methods [4], a sliding window technique for efficient number plate localization based on discrete wavelet transform [5], Morphological

operation, Thresholding operation, Edge detection, bounding box analysis for number plate extraction [6].

In the characters segmentation module, there are also some techniques to address this work such as: edge detection, color model transform, connected components analysis [4], an intelligent framework that outlines character of car number plate by various illuminations [5]. Horizontal projection [8, 19], multi-clustering algorithm [10], threshold and connected components [12], horizontal and vertical projections [13, 15, 18]. Color reverse, vertical edge detection, horizontal projection histogram, vertical projection [9], morphology operation and connected components [19].

In the characters recognition module, there are also many techniques to address this work such as: color image processing [7], hidden markov model [8], support vector machine [9], multi-cluster and multilayer neural networks [10]. Least squares support vector machines [11], multi-layer perceptron network [12, 13], template matching [14], fuzzy multilayer neural network [15], Bayesian framework [16], radial basis function neural networks [17].

Although, there are many method proposed for ANPR system. But, there is not a single method can provide satisfactory performance in all the applications in various complicated background such as: uncertainty of edges, various types of plate, the plate is small, dim lighting, low or high illuminated images, types of plate, colors, character fonts, syntax, size, angle of the number plate, weather and environment, multi-rows, Kannada number plates. To cope with these limitations, we have considered the Indian NP to propose a new method for the Indian ANPR system, which satisfied for all types of Indian NP. This paper is organized as follows: section II introduces Number plate Detection, section III shows the characters segmentation and recognition, section IV shows experimental results and section V is conclusions and the last is references.

## II. NUMBER PLATE DETECTION

The Plate detection phase aims at identifying the number plate area in the image. It is often composed of image pre-processing or plate enhancement phase that helps to enhance the signal in the number plate area and attenuate it elsewhere.

Many difficulties occur during the detection and extraction of number plate due to the following reasons:

1. The efficiency of extraction is affected by complex background in an input image.
2. Variations in the position of number plate in different vehicles
3. Different size plates due to camera distance and zoom factor
4. Plates may have various characters and background colors due to different types of plates
5. Unwanted characters, frames and screws introduce confusion
6. Different font size, font style and different languages
7. Occlusion- plates may be obscured by dirt
8. Inclination – plates may be tilted

Here we have considered all the above difficulties and worked on all of them. Our algorithm is able to recognize the number plate efficiently in all such difficulties as listed above.

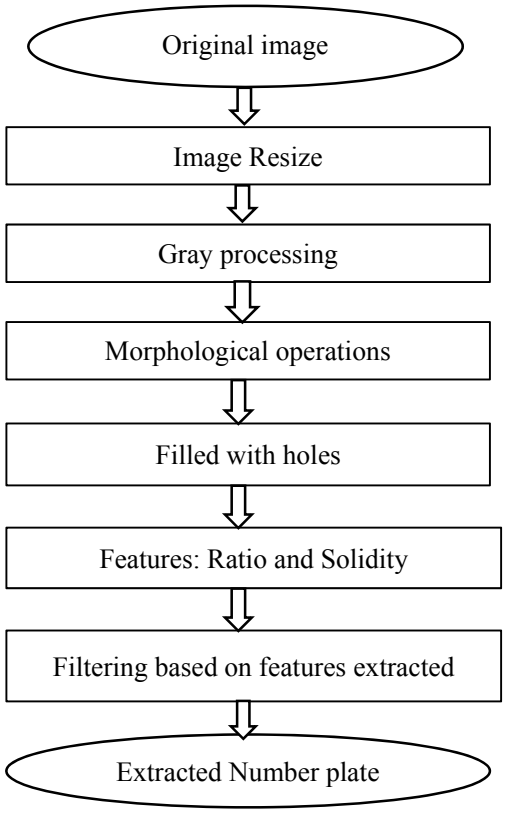



**Fig 1.The overview of Detection process**

**Image acquisition:**

The first step is to acquire the input image of the vehicle. Images are captured by a digital camera at various distances from the camera. The better the quality of the input images are, the better conditions the number plate recognition algorithm has, and thus the higher number plate recognition accuracy can be expected to be achieved.

**Image Resize:**

The image to be segmented is rescaled. Resizing images involves reducing the pixel dimensions and using higher compression. Both of these actions reduce file sizes dramatically.

**Gray processing:**

Grayscale Image is known as an intensity, gray scale, or gray level image. Array of class unit8, unit16, single or double whose pixel values specify intensity values. For single or double arrays, values range from [0, 1]. For unit8, values range from [0, 255]. For unit16, values range from [0, 65535]. For int16, values range from [-32768, 32767]. Gray processing is very important step in image processing, its result is the foundation of later steps. Resized image is converted into gray scale image. Binary images might be too simple and cannot represent the picture character. Color images are too complex and affect the processing speed and they do not help in identifying important edges or other features. The basic concept of gray conversion is to eliminate hue and saturation image while maintaining its luminance. The true color to gray-scale conversion is performed by Gray=0.299r+0.587g+0.114b---------- (1)

Where Gray is the new pixel value and r, g, and b are red, green and blue values of the original pixel respectively.

**Morphological operation:**

Morphological image processing is a collection of non-linear operations related to shape or morphology of features in an image. Mathematical Morphology is a way of nonlinear filters, which could be used for image processing as well as noise suppression, feature extraction, edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression etc.

There are four basic operations of mathematical morphology: dilation, erosion, opening and closing.

**Dilation:** It is defined as the maximum value in the window. Hence the image after dilation will be brighter or increased in intensity. It also expands the image and mainly used to fill the spaces. It is the operation of lengthening or thickening in binary image.

**Erosion:** It is just opposite to dilation. It is defined as the minimum value in the window. The image after erosion will be darker than the original image. It shrinks or thins the image.

**Opening and Closing:** Both parameters are formed by using dilation and erosion. In opening, firstly image will be eroded and then it will be followed by dilation. In closing, the first step will be dilated and then the result of this is followed by erosion.

Opening operation generally makes the contour of objects smoother, and disconnects narrow, discontinuous and remove thin protrusions.

Closing operation makes an outline smooth, it usually eliminates discontinuity and narrows long, thin gap, clears up small holes and fill the ruptures of the contour line.

Here, morphologically open binary image is applied for the binary image from previous stage. It removes small objects. It removes from a binary image all connected components (objects) that have fewer than P pixels, producing another binary image BW2. This operation is known as an area opening. The default connectivity is 8 for two dimensions, 26 for three dimensions. To remove unwanted objects or regions, small dots and very big areas from an image, this operation is used here. We could have used close operation to perform removal of small and big objects from an image but comparatively this method gives better results.

**Filled holes:**

Hole filling may be defined as a background region surrounded by a connected border of foreground pixels. This process makes the detected regions from the previous step a solid object by removing black pixels on white object. This helps in detecting the number plate region.

**Feature Extraction**:

Feature extraction in image processing is a technique of redefining a large set of data into a set of features of reduced dimensions. The result of the previous stage is the retention of a few candidate regions as possible number plates. Now we have to find which candidate is the true region and so two important features are used to discard the wrong candidate regions. These features are aspect ratio, and solidity.

1. **Area**: The area is determined by counting the total number of non-zero pixels within the image.
   Area: A=H x W
2. **Aspect Ratio**: Aspect ratio describes the relationship between the width and height of an image.
   Aspect Ratio = H/W
   Where H is Height and
   W is Width
3. **Solidity**: The ratio of actual area and convex hull area is known as solidity and is an essential for true number plate detection.
   S=Area/Convex Area
   The convex area is the area inside the convex hull of the 2D object. Convex area is the product of Height and Width of the segmented region.

The Aspect Ratio and Solidity are calculated for each segmented regions or objects detected in the previous stage. These values help in detecting the true number plate region.

**Filtering:**

Based on these two feature values true number plate region is detected. The aspect ratio and solidity values are multiplied pixel by pixel level (AND operation). Thus true ROI is detected.

**Extract Number Plate using bounding box technique:**

The bounding box technique is used to extract the number plate region. The minimum row, maximum row, minimum column and maximum column components are used to locate the number plate in terms of bounding box drawn over the binary image. Here in this step, the number plate region is separated out from the whole vehicle image using these vertices or co-ordinate values.

## III. CHARACTER SEGMENTATION AND RECOGNITION:

The Extracted number plate undergoes the following steps for successful character recognition.

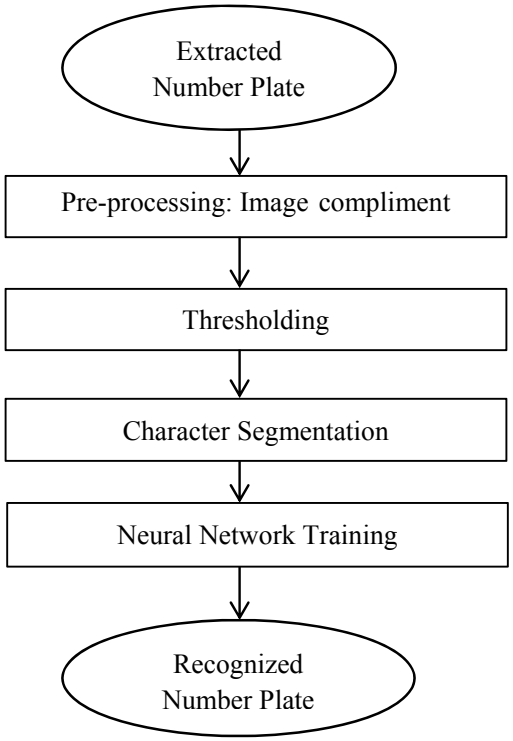



**Fig 2: The overview of Recognition process**

**Pre-processing:**

The detected number plate may contain noise, skew and there may be broken and degraded characters. So, the image is pre-processed to remove the noise, line skew, and to correct the broken and degraded characters. Firstly, the extracted number plate is converted into binary image for further processing. Then, morphological operations like filled holes are used with removal of noise to get a solid object. The noisy, broken characters can be easily detected and could be correctly recognized if the characters are in white pixels with black background. Therefore the black and white number plate image is inverted to get white characters on black background. This is called as complimented image or inverted image.

**Thresholding:**

Thresholding is non-linear operation that converts a gray scale image into binary image where the two levels are assigned to pixels that

are below or above the specified threshold value. The threshold of an image with correct gray scale value is calculated for the purpose of separating the object of interest from background. Thresholding is important to provide sufficient contrast of an image such that, different level of intensity between foreground and background are taken into consideration. The purpose of thresholding is to extract those pixels from some image which represent an object (either text or other line image data such as graphs, maps). For computational purposes gray scale improves the quality of an image and the later computational processes.

Though the information is binary, the pixels represent a range of intensities. Thus the objective of binarization is to mark pixels that belong to true foreground regions with a single intensity and background regions with different intensities.

**Character bounding box for Segmentation:**

Bounding boxes for connected components are the properties of the labeled connected component regions. A bounding box of a labeled region is a rectangle that just encloses the region completely. When a specific bounding box is determined for a connected region, the co-ordinates of the corners of the bounding box and its width and height are available. A bounding box completely specifies the boundaries of the corresponding connected component.

**Character Recognition using ANN:**

**MLP Network:**

A Multi-layer perception is a feed-forward artificial neural network model that maps sets of input data onto a set of appropriate outputs. A MLP consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. These networks have been applied to distinct areas, performing tasks such as function fitting and pattern recognition problems, by using the supervised training with an algorithm known as error back propagation.

In this paper, we proposed an improved method based on MLP neural network and back-propagation algorithm for training to recognize characters & numbers in the Indian NP.

**RBF Network:**

Radial Basis Function Neural Network (RBF) is a local approximation neural network and it is better than Back Propagation (BP) Neural Network in such abilities as approximation, classification and study. The design uses RBF as plate character classifier. RBF is a feed-forward neural network and has simple structure. It has self-features such as optimal approximation and no local minimum, faster convergent speed and simpler topology structure. RBF Neural Network is used to recognize characters with the feature vector as input. This method can recognize characters precisely and improve the ability of number plate character recognition rate.

In our algorithm, the segmented characters were trained using RBF and MLP networks. ANN used in the system uses Feature Vectors as its input. Hence, each character is segmented out from the pre-processed image. Then each character separated is normalized in terms of size and focus so as to resemble the templates that have been used for training the ANN.

Before the character recognition can take place, ANN is trained, so that it can develop the capability of mapping various inputs to the required outputs and effectively classify various characters. For training the ANN, we use vectors generated by the database templates. Different types of features have been used to generate different parameters which are fed to the ANN. Sum squared error is calculated because system needed to calculate the effect of joint errors in all the parameters rather than overall error.

## IV. RESULTS AND DISCUSSIONS

A database of 120 Number Plate Vehicle images was taken containing English characters, Kannada characters, and numerals. The images have uniform illumination with different font size, different font style, Yellow board for two wheeler and four wheeler vehicles. Firstly, Number plate is detected using Thresholding, Morphological operations and Filtering based on the features like Aspect Ratio and Solidity. Each character is segmented from the detected number plate and then for character recognition Artificial Neural Network is used.

The following output stages have been obtained for vehicle number plate images taken by a mobile phone camera. Fig 3(a), (b), (c), (d), (e), (f), (g) and (h) shows the different output stages obtained by using the proposed methodology.

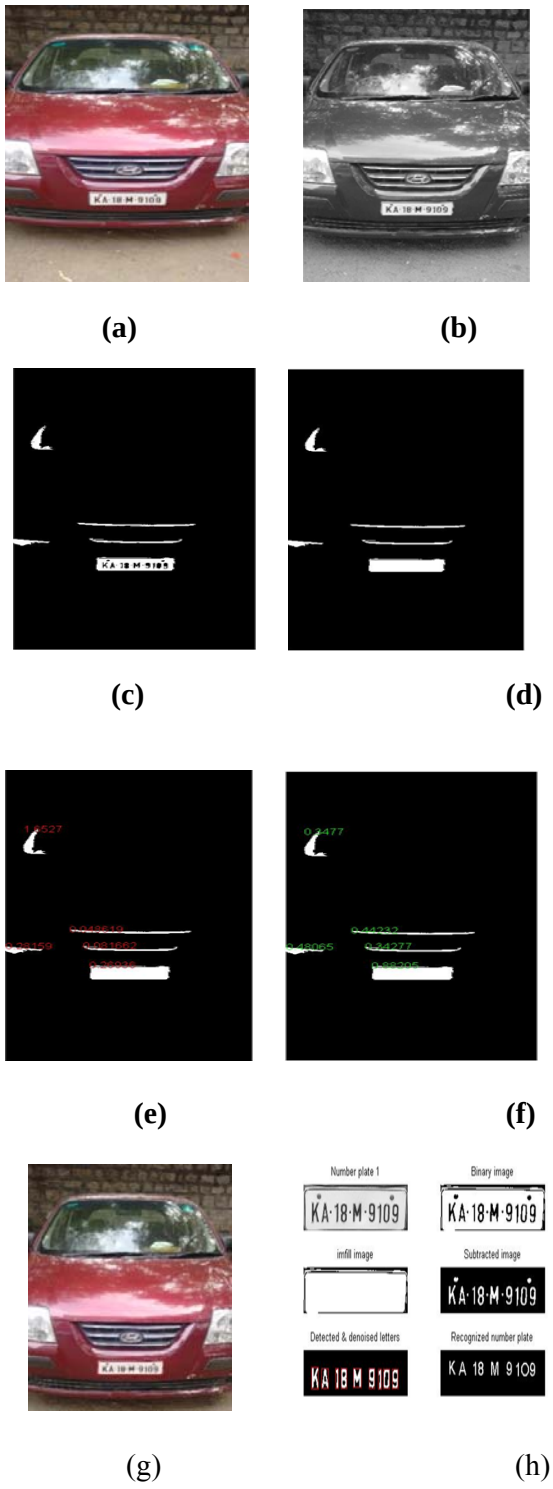



**Fig 3. Vehicle number plate detection and recognition process**

(a) **Image Acquisition:** The input vehicle image captured by a digital camera

(b) **Image Pre-processing output:**Gray scale image obtained by converting color image into grayscale image

(c) **Morphological operations:** To remove small and big regions morphological area opening is performed

(d) **Filled holes:** To get a solid object by removing black pixels on white objects

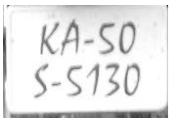
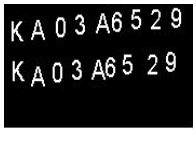
(e) **Features Extraction:** Aspect Ratio for each segmented region is calculated and labeled

(f) **Features Extraction:** Solidity for each segmented region is calculated and labeled

(g) **Detected ROI:** The number plate region is detected and highlighted using bounding box

(h) **Character recognition**

The results were checked for different kind of number plate vehicles. Such as, different font size, different font style, different backgrond color (white and yellow boards), kannada number plates, different states plates, plates with dirt i.e. occluded number plates, number plates with tilt. The same results for different conditions are shown below.

| Input No.plate | Detected No.plate | Recognized No.plate |
|---|---|---|
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

The success rate is calculated for the system, which is measured using the parameter accuracy. The accuracy of the system is obtained by correctly recognized number plates divided by the total number of input images tested.

The result analysis of the system is shown in table 3 below.

| No of images acquired | Correctly recognized number plates | Accuracy |
|---|---|---|
| 120 | 117 | 97.5% |

## V. CONCLUSIONS AND FUTURE WORK

As an overall view of the system it could be concluded that this system has been developed by using techniques mentioned and elaborated earlier in this document which are thresholding and morphological operations for detecting number plate and artificial Neural Network approach to recognize the characters. Besides, the interface of the system is user-friendly and is easier to use. The detection and recognition processes of this system are smooth because of the steps that are used in this system. This system has the capability of detecting number plate for different conditions like different font size, different font style, hand-written characters, kannada characters, different background color for all indian number plates. The proposed method is flexible and not sensitive to image variations. The method is resistant for variations of a size of number plate (within a certain interval). It is important because the position of a car in relation to the camera could vary within given area, so that the resolution of number plate can be bigger or smaller depending on the position of the car.

As an advancement to this system, the future scope of this work is that it can be extended to work for different indian languages and for different environmental conditions like fog and rain.

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