NUMBER PLATE RECOGNITION SYSTEM

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Session: 2014-2018

The Islamia University of Bahawalpur

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1 Introduction

1.1 Objectives

Automatic Number Plate Recognition System ANPR is an essential stage for the automation of traffic system. Use of vehicles is getting increased in today's era that is why traffic control is being tough. It is hard to store and maintain the record of vehicles manually. Automatic Number Plate Recognition System can be used for better control of vehicles and for store and maintain the record of vehicles automatically.

1.2 Problem Statement

Automatic Number Plate Recognition System is the identification system of vehicles. It is an image processing technology used to identify the vehicles only by their license plates. Automatic Number Plate Recognition ANPR plays am major role in management of parking areas, and surveillance of illegally parked vehicles. Since every vehicle has a unique number plate so it can be identified by its number plate. The classification is utilized for the electronic toll-collection system (ETC) and to display available parking spaces to vehicles. The identification is also employed for managing parking facilities, monitoring and analysis of traveling time, and security systems such as observation of stolen vehicles and monitoring of unauthorized vehicles entering private areas [1].

1.3 Scope

Number plate recognition is realized by acquiring images of either the front or the rear of vehicles with cameras and then by image processing to identify license plates. It consist of three main stages. First one is Number Plate Identification & Localization in this segment the visual of the scene is improved with is image processing. Second is Character Segmentation in which characters segmented from the detected number plate for retaining the useful information to the system so that further processing can take place. Third is OCR Optical Character Recognition in which text is transferred into encoded text information.

A feedforward Artificial Neural Network is used which is based on OCR Algorithms.

For this purpose MATLAB matrix library is used. MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java [2].

MATLAB is used for the development of system in very limited time because we don't had enough time for development.

For enhancement of scene MATLAB's image processing toolbox is used this toolbox provide some built-in functions for reading image, cropping it, converting it into binary image then labeling it for accessing the text in the scene.

For machine learning MATLAB's Neural Network toolbox is used. This tool box provide built-in functions for creating network, setting its parameters and its hyper parameters according to the user requirements.

1.4 Applications

ANPR system has many application which are Highway Tool Collection, Red Light Violation enforcement, Border & Custom Checkpoints, Management of parking areas and to display the available space in parking.

1.5 Literature Review

The aim of the Automatic Number plate recognition (ANPR) is record keeping as record keeping is the very difficult job to do manually. In this system our most focus is on reducing the manual work in opening and closing of gate.

The main goal of this work is to design and implement efficient and novel architectures for automatic number plate recognition (ANPR) system, which operates in high definition (HD) and in real time. In addition, a separate ANPR algorithm is developed and optimized, by taking advantage of technical features of digital image processing algorithms. The investigation of the algorithm and its optimization focused on real time image and video processing for license plate (LP) or number plate localization (NPL), LP character segmentation (NPS) and optical character recognition (OCR) in particular, which are the three key stages of the ANPR process. ANPR often forms part of an intelligent transportation systems. Its applications include identifying vehicles by their number plates for policing, control access and toll collection [1].

The distance at which a vehicle plate could be identified using a specified lens at maximum zoom is provided in the work. The distance can vary from 2 feet to 3 feet in some cases. The common guidelines suggest that, to read a number plate, the car should be 50% of the screen height. Specifically (extraordinary lighting conditions, distinctive hues, diverse separation from the camera, and so on), the zone containing the auto tag number turns out to be one of these articles. Once the intrigue ranges are in this manner divided, they are intelligently binarized (with the guide of some measurable strategies and utilizing a few test focuses), and go for facilitate division to the acknowledgment/preparing subsystem [3].

1.6 Proposed system description

The algorithm proposed of this system is specially designed to recognize the license plates of vehicles. First of all system need to train on some collected number plate data and cross validate and repeat that process until machine get learned. When machine learned successfully then further processing will take place.

The input of the system is the image of a vehicle captured by a camera. The captured image is taken from 2 – 3 feet away. That image is processed through Number Plate Extractor (NPE) with give its output to segmentation part [1], [3].

Segmentation part take the extracted plate region and make further processing on it and separates the characters of image and store each character's data in a row matrix.

Finally recognition part recognize the characters through the trained Neural Network and result the plate number.

In whole structure multiple functions of two different toolboxes of MATLAB are used. These toolboxes are Image Processing Toolbox (IPT) and Neural Network Toolbox (NNT).

2 Related Literature

2.1 Basics of MATLAB

MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java.[2]

Key Features

- High-level language for numerical computation, visualization, and application development.
- Interactive environment for iterative exploration, design, and problem solving.
- Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration, and solving ordinary differential equations.
- Built-in graphics for visualizing data and tools for creating custom plots.
- Development tools for improving code quality and maintainability and maximizing performance.
- Tools for building applications with custom graphical interfaces.
- Functions for integrating MATLAB based algorithms with external applications and languages such as C, Java, .NET, and Microsoft Excel [2].

2.2 Digital Image Processing

Image Processing Toolbox provides a comprehensive set of reference-standard algorithms, functions, and apps for image processing, analysis, visualization, and algorithm development. You can perform image analysis, image segmentation, image enhancement, noise reduction, geometric transformations, and image registration. Many toolbox functions support multicore processors, GPUs, and C-code generation [2].

Key Features

- Image analysis, including segmentation, morphology, statistics, and measurement.
- Image enhancement, filtering, and deblurring.

2.2.1 Digital Image Reading

To import an image from any supported graphics image file format, in any of the supported bit depths, use the imread function. This example reads a truecolor image into the MATLAB workspace as the variable RGB [2].

$$RGB = imread('Example.jpg');$$

2.2.2 Image Binarization

Binary images contain Boolean pixel values that are either 0 or 1. Pixels with the value 0 are displayed as black; pixels with the value 1 are displayed as white. Intensity images contain pixel values that range between the minimum and maximum values supported by their data type. Binary images can contain only 0s and 1s, but they are not binary images unless their data type is Boolean [2].

2.2.3 Morphological Operation

- **Opening**
- **Closing**
- **Dilation**
- **Erosion**

The **imopen** function performs morphological opening on an image. The imopen System object performs an erosion operation followed by a dilation operation using a predefined neighborhood or structuring element.

The **imclose** function performs morphological closing on an intensity or binary image. The imclose System object performs a dilation operation followed by an erosion operation using a predefined neighborhood or structuring element.

The **imdilate** function performs morphological dilation on an image.

The **imerode** function performs morphological erosion on an image using a neighborhood specified by a square structuring element of width 4 [2].

2.3 Machine Learning

It is the process of organizing, analyzing and modeling data. Regression and classification is used for predictive modeling. In simple words training the machine to learn. First of we need some data to train the machine after this there is a need to cross validate the learning and at the end we need to test either the results are near to the requirement or not. If the results are near to the requirements it means that our machine is learning well otherwise we need to train the machine again and cross validate again and this process will repeat till our requirement meet.

For learning machine there are number or techniques and many algorithms that we can use.

Here are two types of machine learning techniques:

1. Supervised machine learning
2. Unsupervised machine learning

2.4 Supervised machine learning

Supervised learning (machine learning) takes a known set of input data and known responses to the data, and seeks to build a predictor model that generates reasonable predictions for the response to new data.

Suppose you want to predict if someone will have a heart attack within a year. You have a set of data on previous people, including age, weight, height, blood pressure, etc. You know if the previous people had heart attacks within a year of their data measurements. So the problem is combining all the existing data into a model that can predict whether a new person will have a heart attack within a year.

Supervised learning splits into two broad categories:

1. **Classification** for responses that can have just a few known values, such as 'true' or 'false'. Classification algorithms apply to nominal, not ordinal response values.
2. **Regression** for responses that are a real number, such as miles per gallon for a particular car.

Few Supervised classification learning techniques are

- Logistic regression
- Generalized linear model
- Classification
- Support vector machine
- Artificial neural network

2.4.1 Artifical Neural Networks

Neural networks are composed of simple elements operating in parallel. These elements are inspired by biological nervous systems. As in nature, the connections between elements largely determine the network function. You can train a neural network to perform a particular function by adjusting the values of the connections (weights) between elements.

Typically, neural networks are adjusted, or trained, so that a particular input leads to a specific target output. Typically, many input/target pairs are needed to train a network.

Neural networks have been trained to perform complex functions in various fields, including pattern recognition, identification, classification, speech, vision, and control systems.

Artificial neural network is same as human nervous system. In a neural there are three types of layers:

1. Input layer
2. Hidden layers
3. Output layer

Input layer contains inputs data that we need to feed the neural network. Number of inputs depend on the data samples.

Hidden layers contains some hidden nodes and bias nodes. Number of nodes depends on user and complexity of network and can be increased accordingly.

Not just nodes but hidden layers can also be increased as per requirements. This network will call multilayer neural network.

Output layer contain output nodes. Number nodes depend on the classes of data number of classes and output nodes will remain same [2].

2.4.2 Neural Network Design Steps

We will follow the standard steps for designing neural networks to solve problems in four application areas: function fitting, pattern recognition, clustering, and time series analysis. The work flow for any of these problems has seven primary steps [4].

1. Collect data
2. Create the network
3. Configure the network
4. Initialize the weights and biases
5. Train the network
6. Validate the network
7. Use the network

2.4.3 Topologies of Neural network

Here are some Topologies / Architectures and algorithm that can be used for Artificial Neural Networks ANN:

- Feed forward neural network
- Recurrent neural network
- Multi-layer perceptron (MLP)
- Convolutional neural networks
- Recursive neural networks

- Deep belief networks
- Self-Organizing Maps
- Deep Boltzmann machine
- Stacked de-noising auto-encoders

Non-linear / Logistic regression technique in which Feed forward network algorithm is used is followed here.

2.4.4 Logistic Regression

Logistic regression is the type of predictive model that can be used when the target variable with two categories –for example live/die, has disease/ doesn't have disease, purchase product / doesn't purchase product, etc. A logistic regression model doesn't involve decision trees and more similar to Non-linear regression such as fitting a polynomial to a set of data values. Logistic regression can be used only with two types of target variables:[5]

- A **Categorical target variable** that has exactly two categories (i.e. a binary variable).
- A **Continuous target variable** that has values in the range 0.0 to 1.0 representing probability values or proportions.

2.4.5 Logistic Function

Logistic regression is named for the function used at the core of the method, the logistic function.

The logistic function, also called the sigmoid function was developed by statisticians to describe properties of population growth in ecology, rising quickly and maxing out at the carrying capacity of the environment. It's an S-shaped curve that can take any real-valued number and map it into a value between 0 and 1, but never exactly at those limits [5], [6].

$$Sigmoid = \frac{1}{1 + e^{-value}}$$

2.4.6 Feedforward network

Feedforward networks consist of a series of layers. The first layer has a connection from the network input. Each subsequent layer has a connection from the previous layer. The final layer produces the network's output.

Feedforward networks can be used for any kind of input to output mapping. A feedforward network with one hidden layer and enough neurons in the hidden layers, can fit any finite input-output mapping problem.

2.4.7 Back propagation

Backpropagation is a method used in artificial neural networks to calculate a gradient that is needed in the calculation of the weights to be used in the network. It is commonly used to train deep neural networks, a term referring to neural networks with more than one hidden layers.

Backpropagation is a special case of an older and more general technique called automatic differentiation. In the context of learning, backpropagation is commonly used by the gradient descent optimization algorithm to adjust the weight of neurons by calculating the gradient of the loss function. This technique is also sometimes called backward propagation of errors, because the error is calculated at the output and distributed back through the network layers. The backpropagation algorithm has been repeatedly rediscovered and is equivalent to automatic differentiation in reverse accumulation

Mode. Backpropagation requires a known, desired output for each input value to the weights of the network. This is normally done using backpropagation. Assuming one output neuron, the squared error function is:

$E \ = \frac{1}{2} \ (t - y)^2$, also called 'mean squared error'

Where E is the squared error, t is the target output for a training sample, and y is the actual output of the output neuron.

2.5 Evaluation of supervised Classification Algorithms

In binary classification here are two possible output classes (0 or 1, yes or no, true of false, positive or negative etc.)

1. What measures should we use?
   - Classification accuracy might not be enough.
2. How reliable are the predicted values?
3. Are errors on the training data a good indicator of performance on future data? If the classifier is computed from the very same training data, any estimate based on that data will be optimistic.
   - New data probably not exactly the same as the training data [7].

2.5.1 Confusion Matrix

The Confusion matrix is one of the most intuitive and easiest metrics used for finding the correctness and accuracy of the model. It is used for Classification problem where the output can be of two or more types of classes [7][8].

Predicted Class / Actual Class	Yes	No
Yes	True positives=100	False negatives=5
No	False positives=10	True negatives=50

N=165, Actual yes = 105, Actual no = 60 predicted yes = 110, predicted no = 55.

True positives: *positive tuples correctly labeled*.
True negatives: *negative tuples correctly labeled*.
False positives: *negative tuples incorrectly labeled.*
False negatives: *positive tuples incorrectly labeled.*

Metrics based on Confusion matrix

Accuracy: Overall, how often is the classifier correct?

$$\frac{(TP + TN)}{total} = \frac{(100 + 50)}{165} = 0.91$$

Precision: When it predicts yes, how often is it correct?

$$\frac{TP}{\text{Predicted Yes}} = \frac{100}{110} = 0.91$$

Recall: When it's actually yes, how often does it predict yes?

$$\frac{TP}{\text{Actual yes}} = \frac{100}{105} = 0.95$$

F-measure:

$$2\,\frac{(Precision)(Recall)}{(Precision\ +\ Recall)}$$

$$2\,\frac{(0.91)(0.95)}{(0.91 + 0.95)} = 0.93$$

2.5.2 Case Study of confusion matrix

Suppose we have a two-class classification problem of predicting whether a photograph contains a man or woman.

We have a test data of 10 records with expected outcomes and a set of predictions from our classification algorithm which is shown in Table 2.1

No.	**Expected outcome**	**Predicted**
1	1	0
2	1	1
3	0	0
4	1	1
5	0	1
6	0	0
7	0	0
8	1	1

9	1	0
10	0	0

Let’s turn our results into a confusion matrix.

First we must calculate the number of correct predictions for each class as shown in Table 2.2

1	1	3
2	0	4

We can calculate number of incorrect predictions for each class organized by the predicted value as shown in Table 2.3

1	1	2
2	0	1

2-Class Confusion matrix

Table 2.4 shows 2-class confusion matrix

Actual class	Predicted	
	1	0
Men	3	1
Women	2	4

Total actual men= 3+2 = 5

Total actual women = 1+4 = 5

Correct values are organized in diagonal line from top left to bottom right = 3+4 = 7.

The algorithm made 7 of the 10 predictions correct with an accuracy of 70%.

$$\textbf{Accuracy} \ = \frac{total\ correct\ predictions}{total\ predictions\ made} \times 100$$

$$\textbf{Accuracy} \ = \frac{7}{10} \times 100 = 70\%$$

$$\boldsymbol{Precision} = \frac{CP\ Men}{Predicted\ men}$$

$$\boldsymbol{Precision} = \frac{3}{5} = 0.6$$

$$\textbf{Recall} = \frac{CP\ Men}{Actual\ Men}$$

$$= \frac{3}{4} = 0.75$$

3 Design and Methods used in proposed system

3.1 Proposed system modeling

System modeling is the process of developing abstract models of a system, with each model presenting a different view or perspective of that system. System modeling has generally come to mean representing the system using some kind of graphical notation, which is now almost always based on notations in the Unified Modeling Language (UML). Models are used during the requirements engineering process to help derive the requirements for a system, during the design process to describe the system to engineers implementing the system and after implementation to document the system's structure and operation

We may develop different models to represent the system from different perspectives. For example

1. An external perspective, where we model the context or environment of the system.
2. An interaction perspective where we model the interactions between a system and its environment or between the components of a system.
3. A structural perspective, where we model the organization of a system or the structure of the data that is processed by the system.
4. A behavioral perspective, where we model the dynamic behavior of the system and how it responds to events. [9]

Different models describing the proposed system

3.1.1 System Data Flow Diagram

Data flow diagrams illustrating the processing steps in a system.

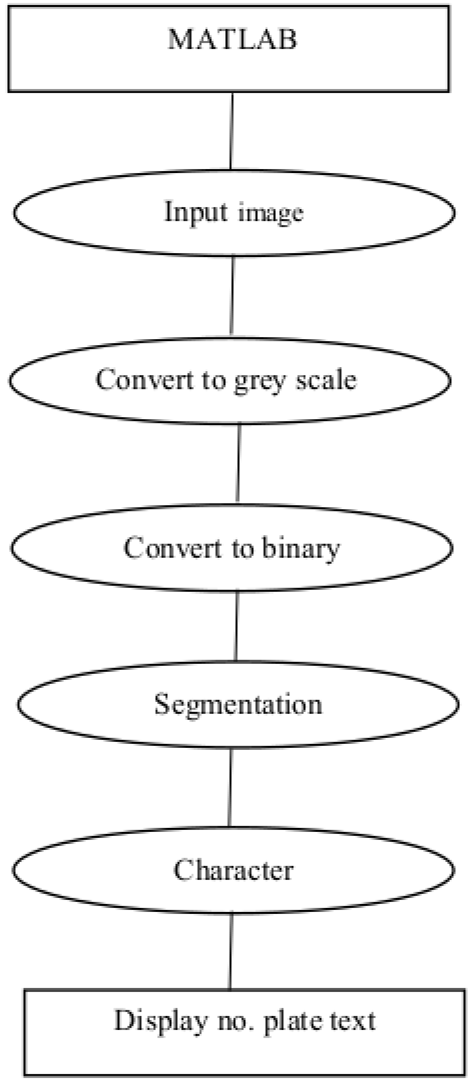


Figure 3.1 Data Flow Diagram of proposed system

3.1.2 Use Case Diagram

Use case diagram describes what a user expects from a system. it represents a discrete task that involves external interaction with a system. In its simplest form, a use case is shown as an ellipse with the actors involved in the use case represented as stick figures.

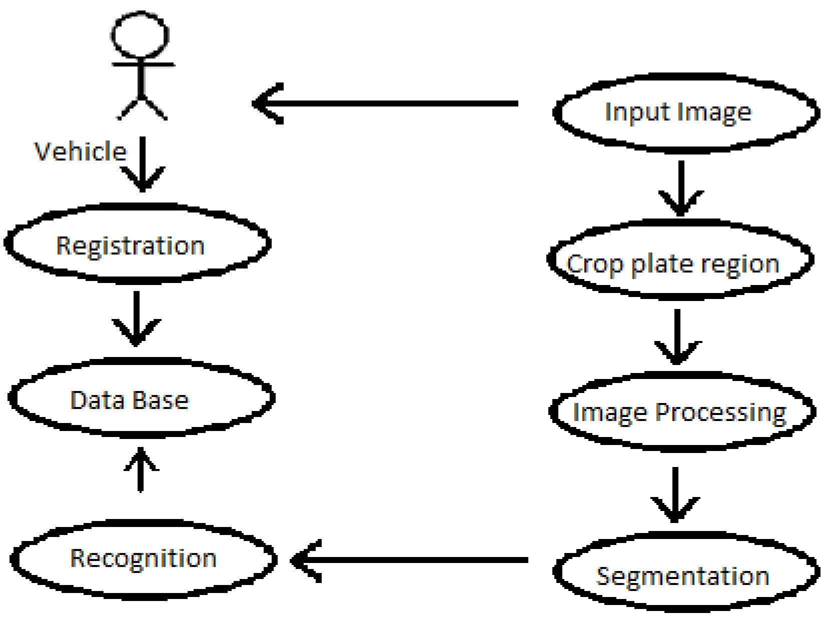


Figure 3.2 Use Case Diagram of proposed system

3.1.4 Sequence Diagram

Sequence diagram represents the interactions between the actors and the objects in a system and the interactions between the objects themselves.

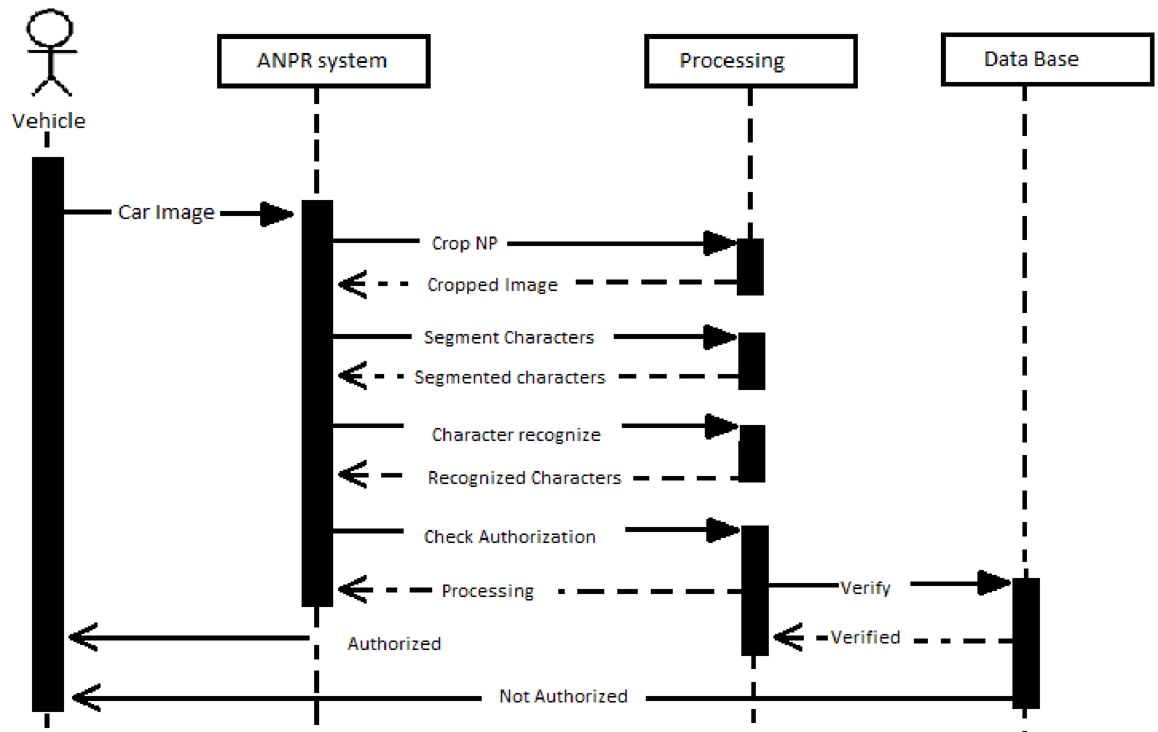


Figure 3.4 Sequence diagram of proposed system

3.1.5 Block Diagram of Image Processing Steps

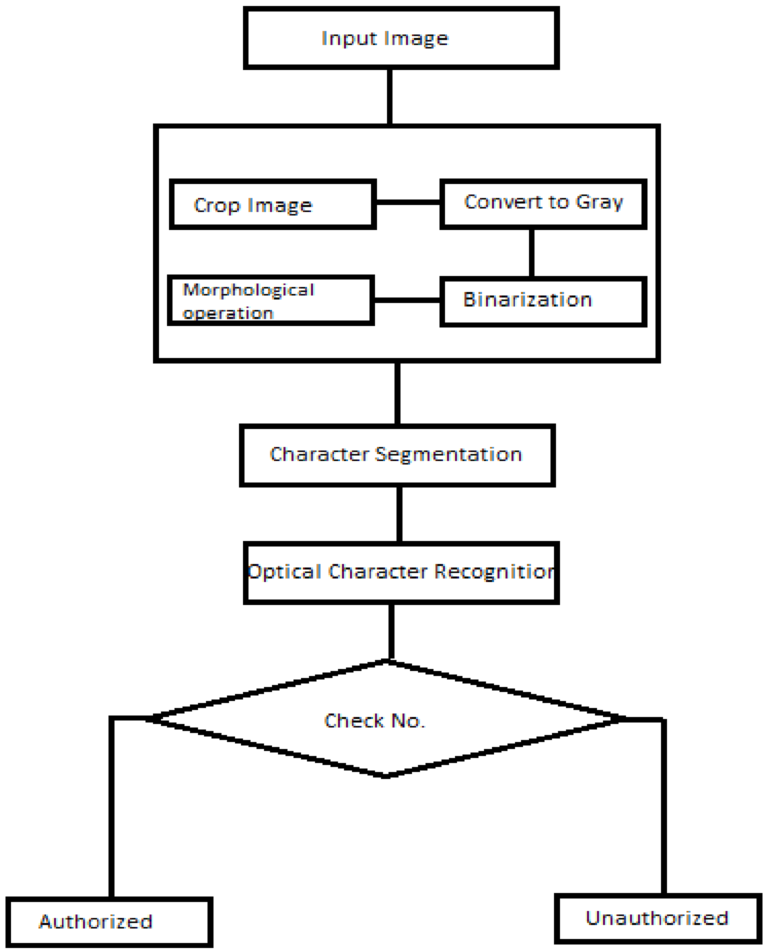


Figure 3.5 Block Diagram of proposed system

3.2 Major modules of proposed system

4 Localization
5 Preprocessing
6 Segmentation
7 Recognition

3.2.1 Number Plate Localization (NPL)

The image taken from web cam or the camera used for this system is then localized, this localization can be done using edge detection technique,

3.2.2 Number Plate Region Extraction (NPE)

After that we need to extract the plate region from the scene or image. Plate region extraction is the first stage in this algorithm. Image captured from the camera is first converted to the binary image consisting of only 1's and 0's (only black and white) by thresholding the pixel values of 0 (black) for all pixels in the input image with luminance less than threshold value and 1 (white) for all other pixels.

3.2.3 Number Plate Character Segmentation (NPS)

In the segmentation of number plate characters, number plate is segmented into its constituent parts obtaining the characters individually. Firstly, image is filtered for enhancing the image and removing the noises and unwanted spots. Then dilation operation is applied to the image for separating the characters from each other if the characters are close to each other. After performing the operations here we have to options foe segmentation of characters either we use regionprops() function for getting the bounding box of each character and then crop it or we just get the highest row and highest column of each character and then crop it. Each cropped character is then resized and stored in row matrix respectively. This datasets is used as the input of the trained neural network for testing either the characters matched or not.

3.2.4 Optical Character Recognition (OCR)

After the segmentation process the last step is the character recognition. For this step the output of the segmentation process is used as the input. Means the segmented characters' output matrix is feed to the neural network and neural network make some processing on it and give the results as text.

Before recognition algorithm, the characters are normalized. Normalization is to refine the characters into a block containing no extra white spaces (pixels) in all the four sides of the characters. For matching the characters with the database, input images must be equal-sized with the database characters. Here the characters are fit to 20 * 20. The extracted characters cut from plate and the characters on database are now equal-sized.

Because of the similarities of some characters, there may be some errors during recognition. The confused characters mainly are B and 8, E and F, D and O, S and 5, Z and 2. To increase the recognition rate, some criteria tests are used in the system for the confused characters defining the special features of the characters. With these features of characters and applied tests during recognition algorithm, recognition rate is increased with the minimum error [1], [10], [11].

4 Experiments

In this chapter we explain the experiments of Proposed system.

4.1 Training

First Train the neural network using Scaled Conjugate Gradient technique

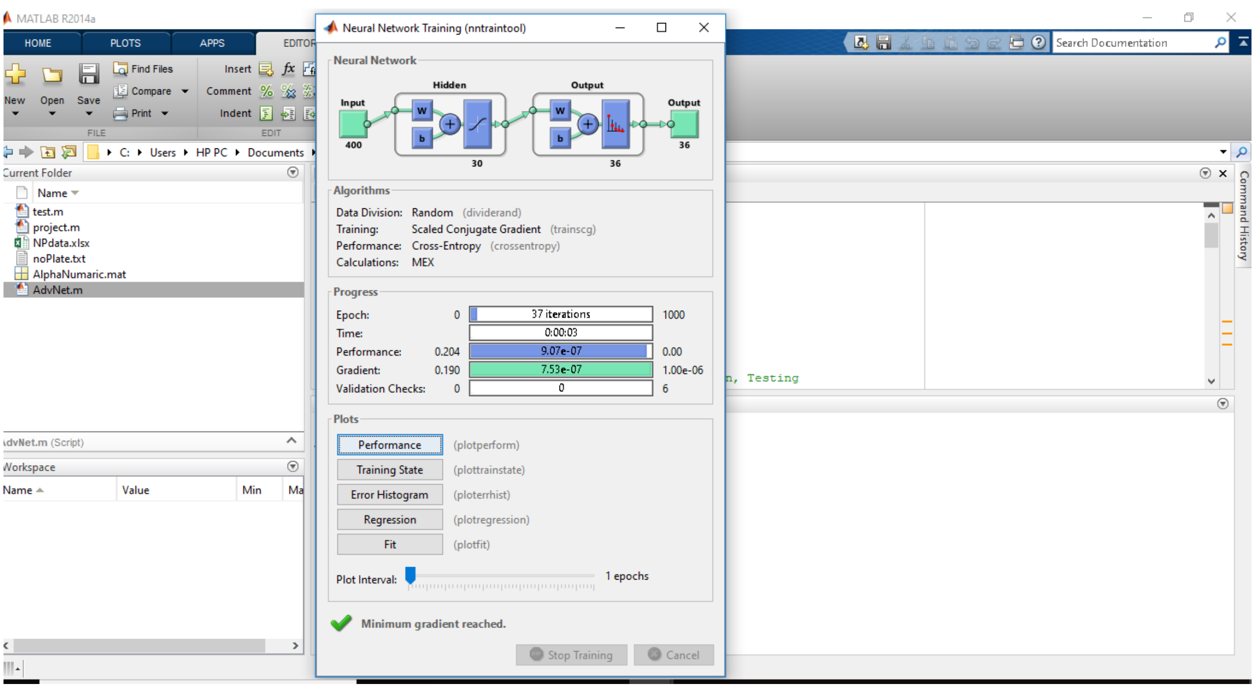
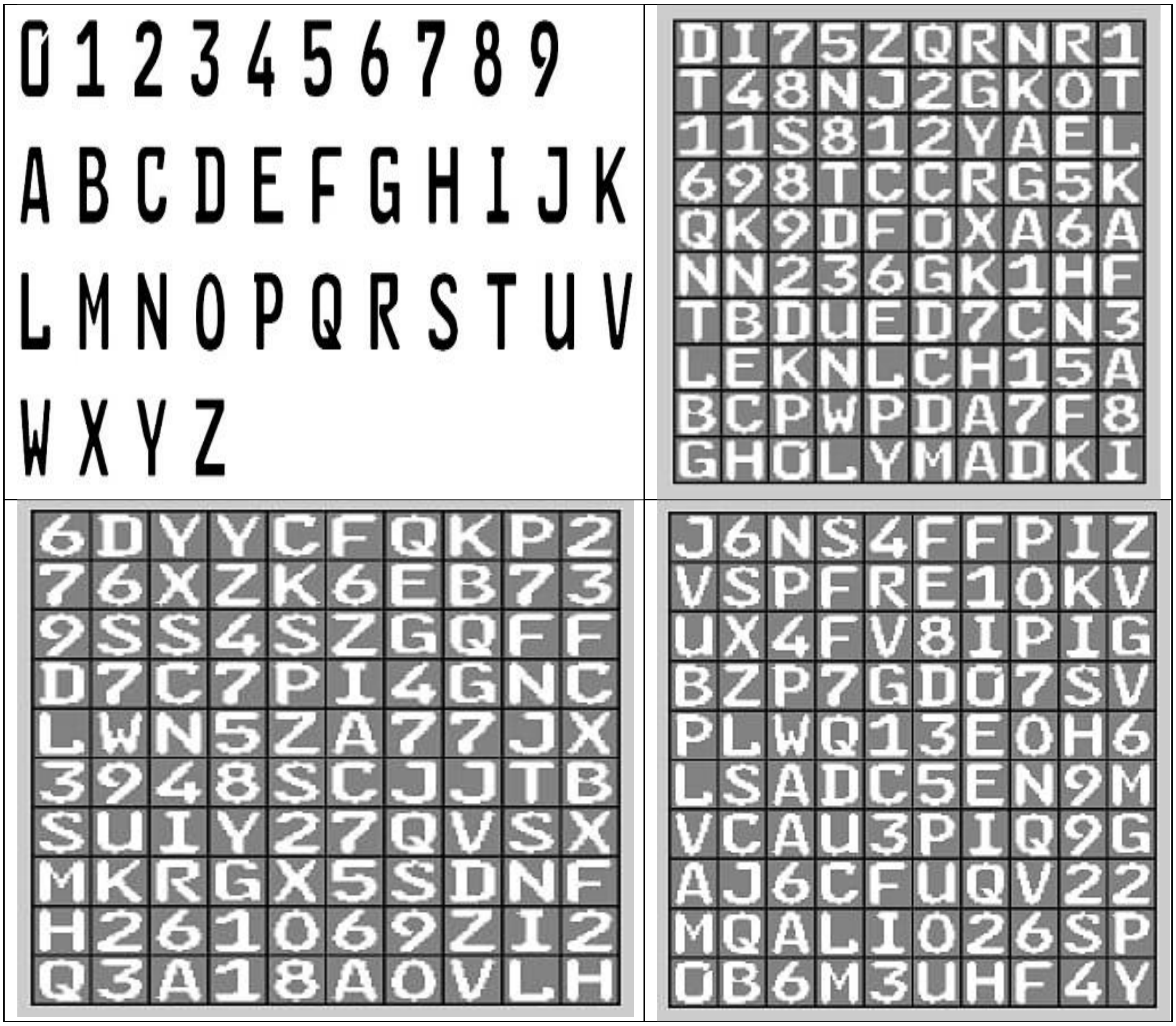


Figure 4.1 Training of neural network

4.2 Dataset images



4.3 GUI of Proposed system

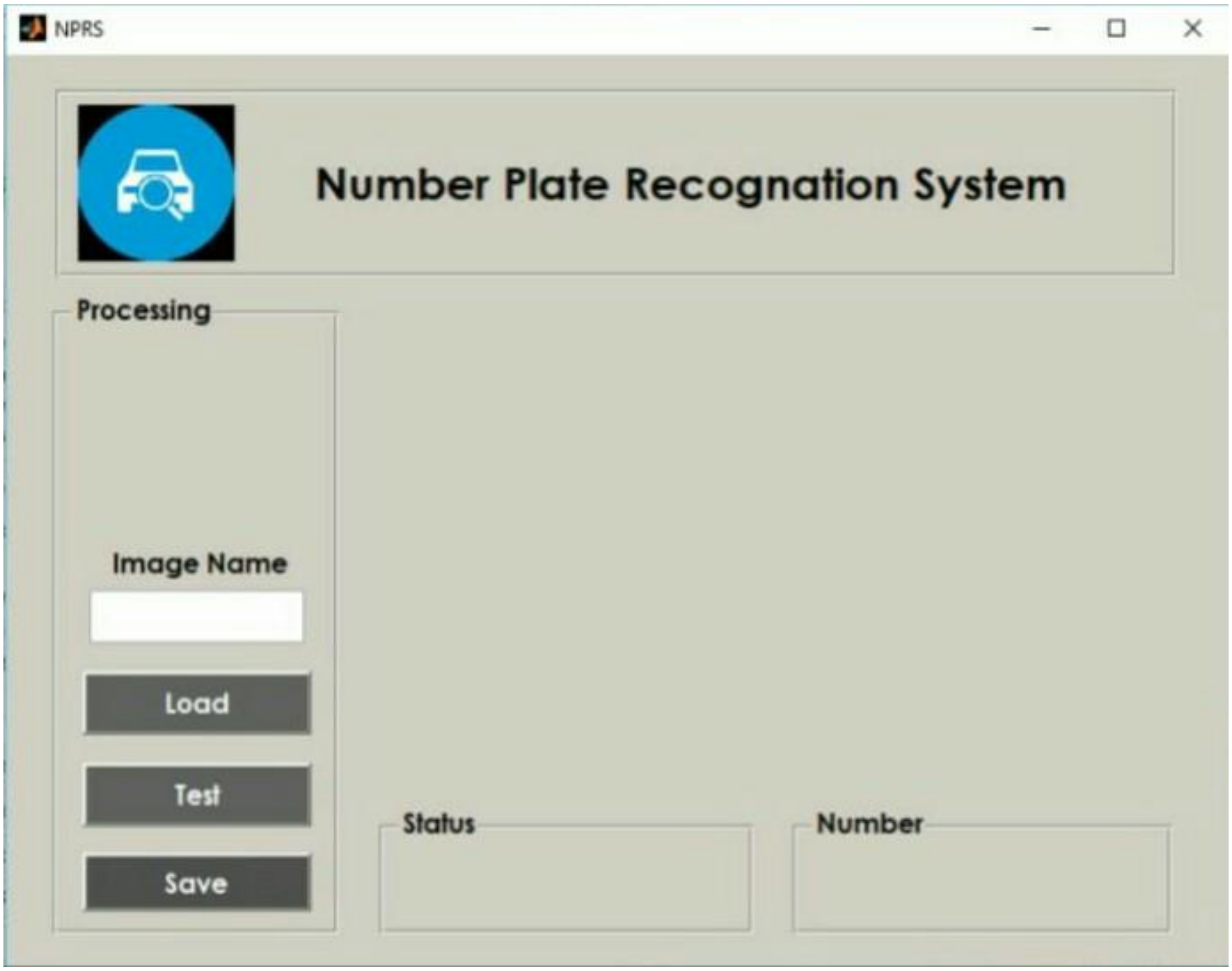


Figure 4.2 GUI of Proposed system

4.3.1 Load Button

By clicking on Load Button a selected image show on GUI.

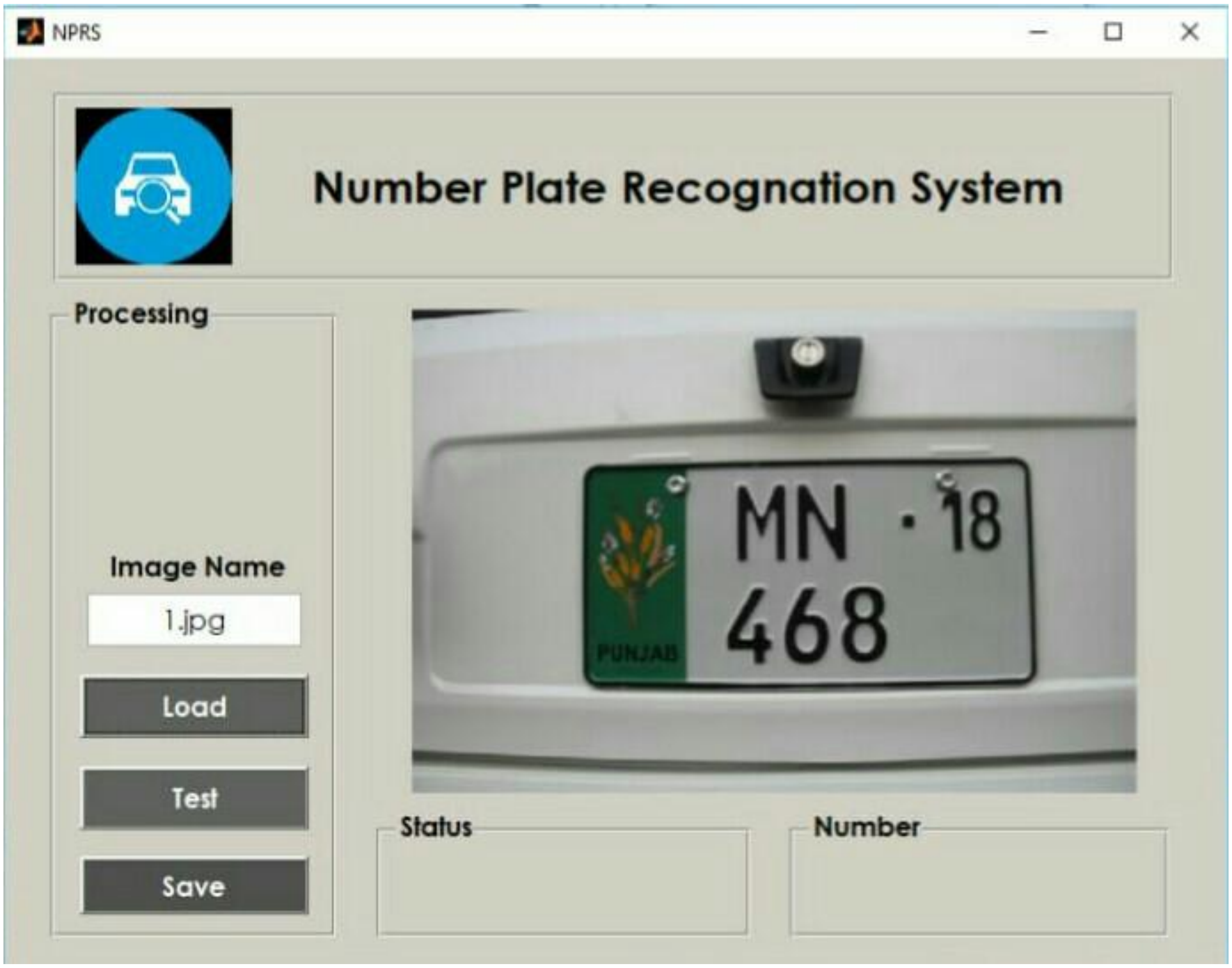


Figure 4.3 Load Button of GUI Proposed system

4.3.2 Test Button

By clicking on Test Button, System extract the number plate number from image and show in Processing area of GUI. System will compare the extracted text of number plate to the saved number plate number of authorized car and show the Status either it is authorized or not

Figure 4.4 Test Button of GUI Proposed system

4.4.3 Save Button

New record can be save by clicking on Save button.

5 Limitation and Future Work

5.1 Limitations

Due to time constraints Database could not be created.Record saved in Excel.

5.2 Future Work

In future, Image capturing system will install. Camera will place on door, when car will arrive camera capture picture of front of car then localize the number plate and do further recognition process. If number plate is authorized then door will open otherwise an alarm will ring.

6 Conclusions

In ANPR system, the picture of vehicle number plate is taken with the camera and the license number of the vehicle is perceived with the goal that the data and information of the vehicle owner can be obtained. In our proposed system, we have performed a technique in which the picture of the vehicle plate is taken. At that point, the noise diminishment is performed on it to show signs of enhancement come about. After this, segmentation and binarization is performed. We make a matrix dataset of characters and train it on neural network then identification of characters are done using trained neural network.and

Refrences

[1] Y. Wen, Y. Lu, J. Yan, Z. Zhou, K. M. Von Deneen, P. Shi, and S. Member, “An Algorithm for License Plate Recognition Applied to Intelligent Transportation System,” vol. 12, no. 3, pp. 830–845, 2011.

[2] S. B. MathWorks team, John N. Little, Cleve Moler, “Image processing And ANN Artificial Neural Networks ToolBoxs.” John N. Little, Cleve Moler, Steven Bangert, Natick, Massachusetts, United States.

[3] C. A. Rahman, W. Badawy, C. Tn, A. Radmanesh, and C. Tp, “A Real Time Vehicle ’ s License Plate Recognition System,” pp. 4–7, 2003.

[4] “Shallow Networks for Pattern Recognition, Clustering and Time Series - MATLAB & Simulink.” .

[5] M. Strano and B. M. Colosimo, “Logistic regression analysis for experimental determination of forming limit diagrams,” *Int. J. Mach. Tools Manuf.*, vol. 46, no. 6, pp. 673–682, May 2006.

[6] J. M. Hilbe, *Logistic regression models*. CRC Press, 2009.

[7] “Simple guide to confusion matrix terminology.” .

[8] “Performance Metrics for Classification problems in Machine Learning.” .

[9] I. Sommerville, *Ninth Edition*. .

[10] S. Du, M. Ibrahim, M. Shehata, and S. Member, “Automatic License Plate Recognition (ALPR): A State-of-the-Art Review,” vol. 23, no. 2, 2013.

[11] H. A. Hegt, R. J. De Haye, and N. A. Khan, “A High Performance License Plate Recognition System Eindhoven University of Technology,” 1998.