Automatic Bengali License Plate Detection And Recognition Using Neural Networks

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Declaration

It is hereby declared that

1. The thesis submitted is our own original work while completing degree at Brac University.

2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.

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Abstract

Automatic license plate detection and recognition has become one of the obligatory components in the field of smart traffic control systems in Bangladesh. However, Automatic License Plate Recognition (ALPR) can also be beneficial for parking lot management systems, detecting stolen vehicles, toll management systems, finding convicted vehicles, which are involved in road related violations etc., and other purposes. In order to ease the smart traffic control system, the license plate detection and recognition process needs to be very efficient.Various methods have already been introduced in order to make the detection and recognition process efficient. Since there have been very few works conducted on Bangla license plates, these methods are not quite efficient due to wide variation in Bangla license plates. Therefore, we have developed a new method using multiple algorithms to increase the efficiency of detection and recognition process. Our proposed method is composed of three stages which are Detection, Segmentation and Recognition likewise most of the conventional license plate recognition systems. We have applied different existing algorithms such as Canny edge detection algorithm, Otsu image binarization algorithm etc. in different stages. We have achieved an accuracy of around 95% by using our proposed method.

Keywords: License Plate Detection, Segmentation, Recognition

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Table of Contents

List of Figures

List of Tables

Nomenclature

The next list describes several symbols & abbreviation that will be later used within the body of the document

$ALPR$ Automatic License Plate Recognition System

ANN Artificial Neural Networks

$BRTA$ Bangladesh Road Transport Authority

CCA Connected Component Analysis

GDA Gradient Descent with Adaptive back-propagation

HMM Hidden Markov Demonstrate

LM Levenberg-Marquardt back-propagation

OSS One Step Secant

$ROID$ Region of interest detection

SAT Segmentation with Adaptive Threshold

SCG Scaled Conjugate gradient

SVM Support Vector Machine

Chapter 1

Introduction

Vehicle number is maximizing in the roads day by day in Bangladesh which results in more vehicle related issues such as traffic rules violation, reckless driving etc. In order to tackle these issues our country is trying to go for a smart solution like automatic license plate detection and recognition system that most of the developed countries around the world are already using.

1.1 Automatic License Plate Recognition

Intelligent Transport Management System has great features and one of that is the ALPR system. There are 3 phases of a properly functioning ALPR system they are,

a. Detection of vehicle's license plate from an image of the vehicle.

b. Character and digit of license plate segmentation.

c. Segmented characters and numbers recognition.

ALPR system of two types such as mobile and stationary ALPR systems are mostly used. For stationary systems cameras are placed on boards of road, lamps on street, roadside buildings to monitor vehicle movements. Some cameras running software in it are competent of detecting the patterns of pixel of the license plates and translate to a digital format. Demodulated data of the license plate is then analogized with a database which consists information belonging to a group of vehicles. An alert is sent to the designated personnel if the database detects any match. For mobile ALPR systems, vehicles which are in motion are mounted with cameras as a result when the vehicle moves from one place to another it is able to take pictures of the license plates of other vehicles and conveys the data extracted from the license plate for comparison to the system. Our focus will be only on stationary ALPR systems.
Some images of stationary and mobile ALPR systems are given in figure 1.1. figure 1.1(a) and 1.1(b) two stationary ALPR system in Frankfurt, Germany and CCTV cameras on a road. Figure 1.1(c) and 1.1(d) two mobile ALPR systems functioning in Qatar and Stockholm placed at the top of the vehicle.

Recognition using the ALPR system is not always successful for various reasons or difficulties. For example, usage of low-resolution cameras results in poor quality image, blurry image due to high vehicle speed and low contrast also disrupts license plate recognition process. However, these problems can be solved by using high resolution camera with high shutter speed which can be expensive.

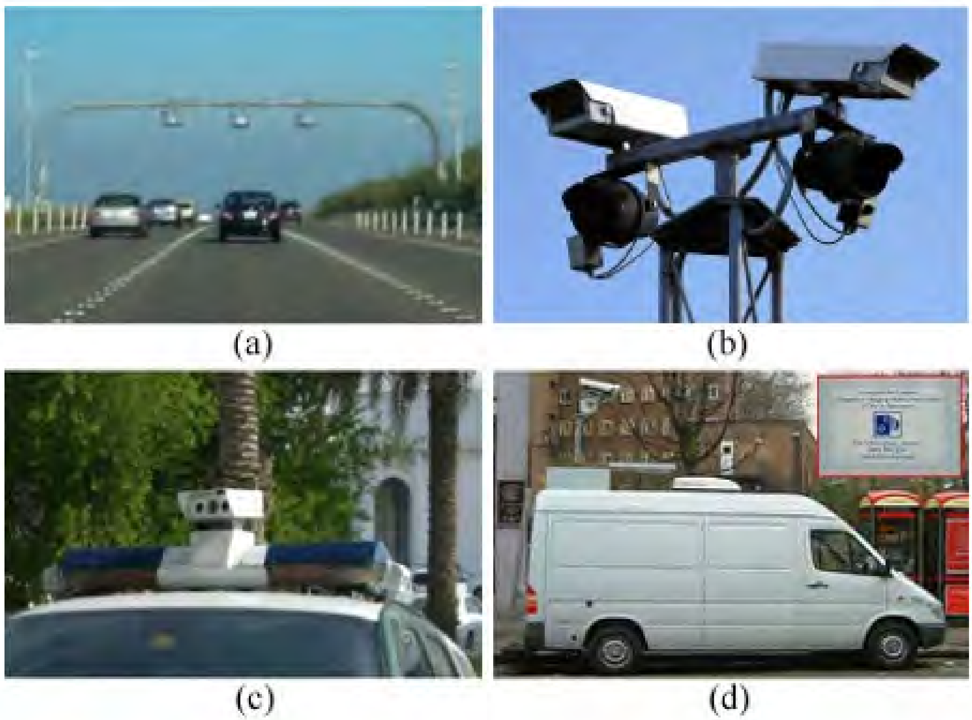

Figure 1.1: Stationary ALPR systems: (a) Frankfurt, Germany (b) CCTV on road Mobile ALPR systems: (c) Qatar (d) Stockholm

1.2 ALPR Applications

Applications of ALPR are numerous. For example, efficient traffic surveillance, finding out stolen cars, identification of cars with arrest warrant, identifying high speed vehicle by time comparison between image taken from one stationary camera and another stationary camera, parking management etc.
ALPR system plays a very vital role in Intelligent Transportation System (ITS) as it is very conducive. Malleability and independence in systems of toll collection in highways and bridges. Reduction in traffic and time as toll collection can be done without manual labor.Urbanization can be done is ALPR system is implemented to manage traffic not only in peak but also in off peak hours. Law and order can be implemented properly if the police department can use the ALPR system to effectively apply the traffic rules, it will also reduce the risk of stolen vehicles. Safety of the country's border can also be ensured by applying the ALPR systems. Simultaneously applications likes encyclopedic database for movement of traffic, flexible and independent harbor provision, security of road by monitoring it these all can be implemented using ALPR systems. Vehicle scrutiny is another important application as it will help in identifying wrong doings in gas payment and keep note of it. ALPR system can be merged with parking system for proper management as through this parking will be more efficient and the flow control of cars entering and exiting the premises can be maintained effectively. And recognizing the license plate will be an extra added benefit in the case of parking systems. Parking lots which will be equipped with the ALPR systems will have many benefits such as automatic entry and exit of vehicles, informations of parked cars and slots of car parking left, also this will help in contributing to maintain the traffic laws. Many

more implementations of the ALPR system can be of recognizing vehicles using the timign and the date of the stamps which will help to know the location as well. Thus ALPR systems can be implemented in various sectors which will give conducive results overall.

Figure 1.2: Vehicle license plates from different countries

1.3 Bangladeshi License Plate

Different countries have different license plate as a result one country's ALPR system cannot be used by another country to use it to detect and recognize the license plate. Specific changes are needed to those ALPR systems that is they need to be modified for using it in another country according to the license plate. In Bangladesh no such ALPR system has been made to detect the license plate successfully according to our research.

Bangladeshi license plates are of very unique features. Bangladesh license plates has letters which are joined by the use of matras which are a line at the top and this makes it more difficult to detect the individual characters. Some of the characters of Bangla has two or greater regions as well. This makes the detection of the characters a bit time consuming and difficult. In Bangladesh we can also see a lot of differences in the pattern and the design of the license plate if compared to that of other countries. Bangladesh license plate can be divided into 5 categories. The government of Bangladesh only provides the number of registration and the license plates are made by the owners according to their wish. So thus the license plate shows variation from each other as a standard template is not followed for making it. And this makes it more confusing and difficult to find the license plate from the image of the vehicle.
Furthermore, it is seen that in the license plates of Bangladeshi vehicles mostly two line of rows are present where the first one is for the information of area and the second row indicates the number. Furthermore it can be seen in Bangladesh that the license plate might have extra rows that means extra information needs to be extracted so this makes the task more difficult as more characters and digits need to

Figure 1.3: Some Bangla license plates with complex background

be extracted. We can divide the Bangladeshi license plates into 5 groups. The groups are public, private, military, government, and foreign missions. Public and private license plate follows the same template that is it has 2 rows mainly and these rows contain information of registration area and registration number.Registration area indicates the location of the place from where the vehicle has been registered and the registration number is denoted by Bangla digits which is usually a six digit number. The main changes in these two license plate is the background and foreground color. For private license plate the background is in black color while the characters and digits are in white but for public license plate it is vice versa. In many cases both public and private license plate can be found containing only one row that depicts all the information. Only one row can be seen in government, military, and foreign mission license plates. For government license plate the background is usually of yellow color and the foreground is of black color. Bangla characters are present which denotes registration type and that is followed up by registration number of five digit. Military vehicles are seen to have an arrow sign and it can also have the abbreviated form of the name of the military force it belongs to.. Foreign missions license plate are and the government license plate follows the same format. Figure 1.4 depicts the different types of license plate present in Bangladesh.

Figure 1.4: Different types of Bangla license plate: (a) Private, (b) Public, (c) Government, and (d) Military.

ক	খ	গ	চ	জ
ঝ	ট	ড	ঢ	ম
প	ফ	ব	ল	ন
স	য	হ	ই	ঙ
ভ	ও	ঞ	◌ে	◌া

Figure 1.5: List of Bangla character that we recognize using neural network.

Registration number of the vehicles are published by Bangladesh Road Transport Authority (BRTA). They are the only one company in Bangladesh to do so. AT present twenty-nine offices of BRTA are operating in Bangladesh. In the figure 1.5 it depicts the list of Bangla letters that can be recognized by the use of neural networks.

1.4 Incentive Scheme

For Bangladesh a stout and potent ALPR system is required. Research conducted by us tells that no stout ALPR system is available in Bangladesh to detect the license plate in an efficient manner. So we have developed an ALPR system in our thesis. The system we developed has three phases similar to other ALPR systems. At the first stage position of the vehicle is located from the image inputted by the application of the algorithm named property of symmetry. Using the Region of Interest Detection (ROID) algorithm at first the license plate is found out. Secondly the extraction of the information of registration from the license plate is done. Segmentation with Adaptive Threshold (SAT) algorithm is used to separate the digits and letters. Artificial Neural Network (ANN) is then used for the task of recognition of the characters and digits that have been segmented before. 32×32 size binary image's prevision are used as attributes to identify them. Our algorithms were tested using 250 images of vehicle which had the number of the license plate in it which is in Bangla language. Experiments show that the system proposed by us for detecting and recognizing the license plate of Bangladesh are much more superior than the algorithms that are already present. Application of our algorithm on English license plate gives us the same result. Thus it is as effective for English license plate also.

1.5 Association of this Thesis

The coalition of the rest of the thesis is done by the following way - Algorithms and technologies that bolster the work and have played an vital role in our scheme have been described concisely in Chapter 2. Analyzing of the existing formulas and simulation that are present in the phases of ALPR system are discussed in chapter 3. ALPR systems that are existing already with its pros and cons have been explained as well as to implement an all-encompassing ALPR system, the set of formulas and algorithms used for detecting and recognizing the Bangla license plate is proposed in Chapter 4. The results of our incentive scheme achieved after conducting experiments and its comparison with the results of other existing strategies are presented in Chapter 5. All in all the conclusion statement along with some propositions for developing the project in the future are procured in Chapter 6.

Chapter 2

Supporting Algorithms and Techniques

2.1 Introduction

We used a couple of existing algorithms and tactics for implementing ALPR system on Bangladeshi vehicles . Such as, , symmetry detection algorithm, projections, extrema detection, artificial neural networks, edge detection, image binarization, moving average filters etc. In this chapter we will describe these algorithms and techniques along with mathematical explanations in brief. Furthermore, we made analytical comparison among the variants of these techniques. Application and role of these techniques in our proposed scheme are also explained.

2.2 Detection of Edge

There is a significant importance of Edge Detection technique in image processing sector. In order to detect modification in an image this technique is used. It also detects and potential features in a given image. Moreover, in order to capture targeted objects in an image edge detection can be very useful. While performing[32] these actions connected curves are generated by edge detector. It specifies the boundaries of the targeted object. It can also consume essential attribute of the objects in the image. There are several edge detection algorithms which can find edges in an image. We used three of the most commonly used algorithms such as Canny edge, Vertical edge and Horizontal edge detection algorithm. Pros and cons of this algorithm is explained in the later parts.

2.2.1 Horizontal and Vertical edge

Using Eq. 2.1 and 2.2 horizontal and vertical derivatives G(i, j) of the given grey-scale image are calculated. Using two steps [18], Vertical and horizontal edge image are calculated. First, the threshold is applied on extracted images then the horizontal edge and the vertical edge images. Threshold is adjusted according to the nature of the input images. Effective way to detect horizontal and vertical edge **6**images show effective performance on detecting rectangular objects in an image of license plate. License plates consist of horizontal and vertical edges. If any one pair can be successfully detected, It becomes easier to locate all four corners of license plate. It

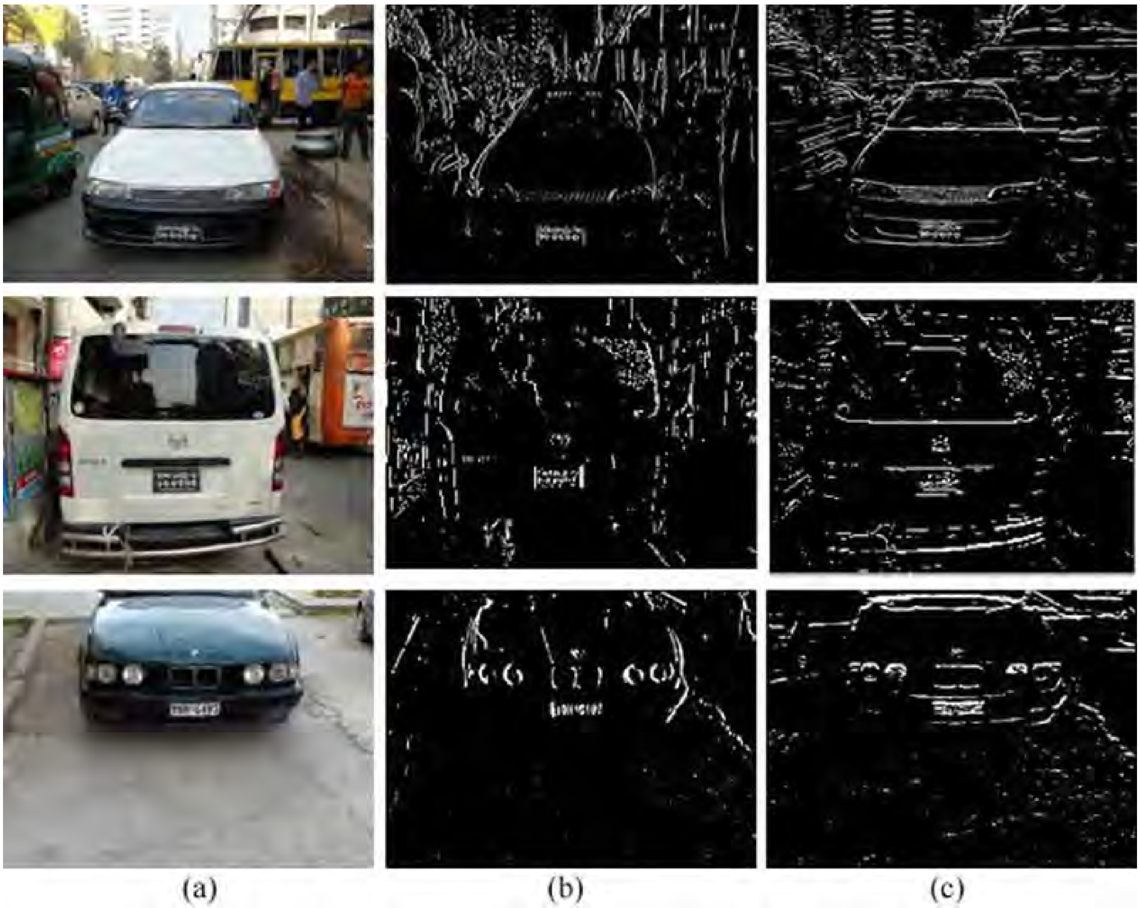

Figure 2.1: (a) Original input images (b) Vertical edge image and (c) Horizontal edge image.

is quite simple as horizontal and vertical edge images always maintain major structural properties of an object. Some associated vehicle images are shown below.

$$\mathrm{D}^h(i,j) = \frac{1}{3}\sum_{x=i-1}^{i+1} |G\,(x, j-1) - G\,(x, j+1)\,|$$

$$\mathrm{D}^v(i,j) = \frac{1}{3}\sum_{y=j-1}^{j+1} |G\,(i-1, y) - G\,(i+1, y)\,|$$

$$E\,(i,j) = \begin{cases} 1, & if D\,(i,j) \geq T < 0 \\ 0, & otherwise \end{cases} \quad 1 \leq i \leq H, 1 \leq j \leq W$$

2.2.2 Canny Edge Detection Algorithm

John Canny first introduced this algorithm in 1986. This algorithm consists of multi-stage. It can identify different edge within an image. The algo. is comprised of three main**52** condition. First condition is such that, error percentage [30] must be very low. It indicates to the ability to identify every edge and avoiding false edges. The next criterion refers to localization which clarifies there should be a minimal distance between local and actual edges. Lastly, third criteria is about minimal response. It says each edge should have only one response. Canny Edge is used in computer vision and image procession sector because of its proficiency. We

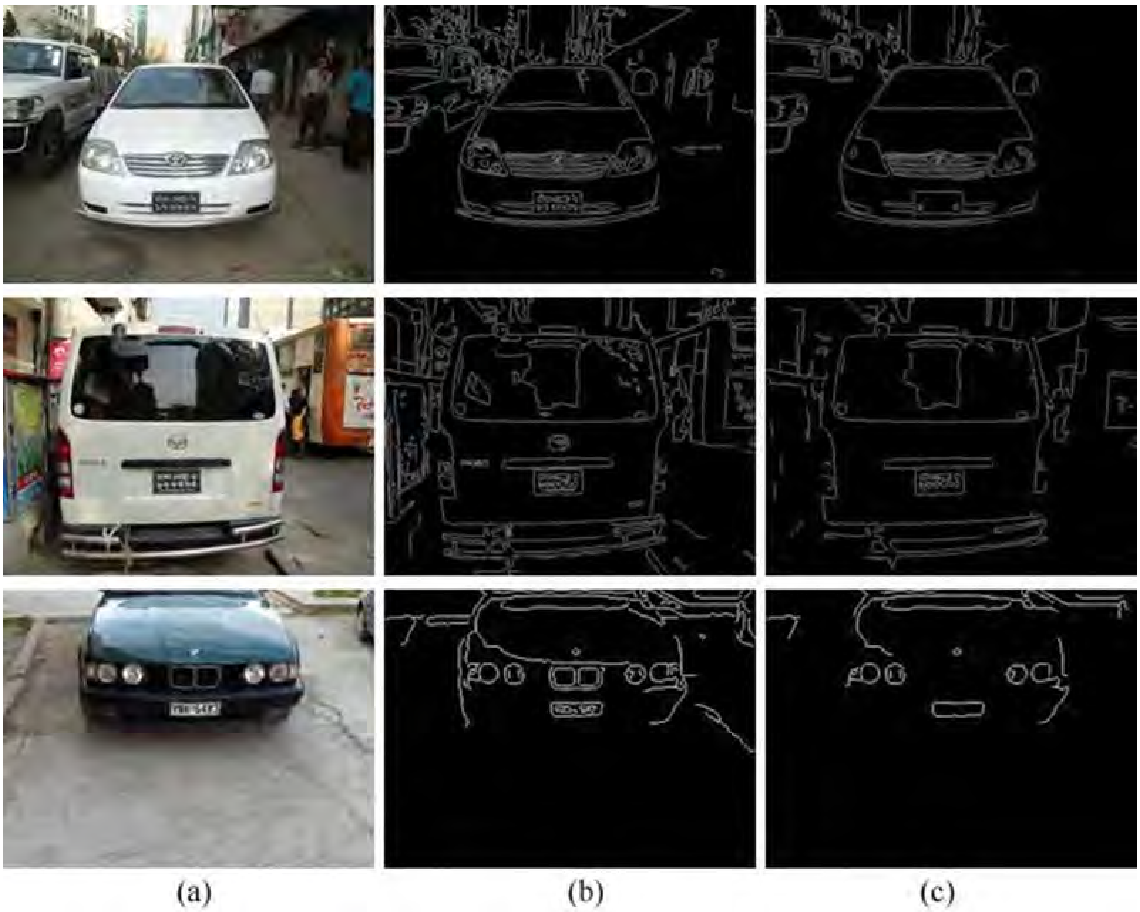

Figure 2.2: (a) Input images (b) Canny edge images (threshold = 0.5) (c) Canny edge images (threshold = 0.4).

used this algorithm in order to identify the region on license plate region. Canny edge detection algorithm has a capability to eliminate many edges which are not necessary in the vehicle image while conserve the edges of the license plate region. In the fig. described below, a set of vehicle images and their respective canny edge images are shown below where each image having fixed threshold value of 0.4 and 0.5.

2.3 Binarization

The method of image conversion into two hundred fifty-six gray levels in white and black image is called image binarization. Before optical character recognition for performing pre-processing binarization is the most widely used method. Choosing a global threshold value and classifying all pixels as black and white according to the threshold value is the most simplistic way for gray scale to binary image conversion. It is not ideal to use global threshold because there is some variety among images illumination for[32]4 example images can be bright or dark as a result global threshold is not capable of providing optimal result in all scenario. It is very difficult or even not possible to find a common threshold for all the image sets. To solve this issue adaptive threshold is required because it is capable of choosing perfect threshold for every image region.

2.3.1 Sauvola Image Binarization Algorithm

Local statistics for example variance, means and range or their combinations of logic defines the threshold value. In most cases, it is local adaptive approach for having[23] multiple adjustable parameters where a function of the coordinates (x, y) refers to threshold . In accordance with local mean and standard deviation, this approach adjusts the threshold.

$$T(x,y) = m(x,y) + \left[1 + k\left(\frac{\sigma(x,y}{R} - 1\right)\right] \tag{2.4}$$

where (i, j) and m(i, j) are standard deviation. Sauvola algorithm is made adaptive by means of standard deviation. For instance., the threshold value is lowered for areas which are badly[29] illuminated. After that binarization of the image is performed by using

$$BI(x,y) = \begin{cases} 1, & if I(x,y) \geq T(x,y) \\ 0, & if I(x,y) < T(x,y) \end{cases} \tag{2.5}$$

2.3.2 Otsu Image Binarization Algorithm

In the algorithm of Binarization given by Nobuyuki Otsu, an optimized threshold is chosen for input image. And this this process is made possible by escalating a contrapositive **14** specification. Otsu's method conduct an inquiry for an optimal threshold value between range. So that, this function given below can attain its maximum:

$$J_{Otsu}(T) = \frac{P_1(T)\,P_2(T)\,[m_1(T) - m_2(T)]}{\sigma^2} \tag{2.6}$$

Some original greys scale images are shown below. In binarizing license plate containing dark background, Otsu's algorithm offers a immensely better result than that of Sauvola although savoulas algorithm is widely used for this purpose. If a constant threshold is implemented in order to binarize all image, it will end up failing to show a satisfactory performance since the license plates will certainly have different degree of brightness In our scheme we applied the algorithm given by Ostu as it consider [12] the brightness level present in the image while producing separate threshold for binarization process.

2.4 Symmetry Detection

An artificial entity has a number of significant attributes. Symmetry is one of the prominent among them. Symmetric is something where one side is a mirror image of the other. An symmetric object can be divided equally to the left and right. [26]In a similar method if we observe then we can notice that most of the automobiles are of symmetric shape. Our intention is to use this unique characteristic property in order to detect the vehicle in an image. In case of finding out a symmetric combination is unable to make noticeable impact. Computing symmetries in an binary image can

Figure 2.3: (a) Original input images, (b) Binarization using Otsu's algorithm, and (c) Binarization using Sauvola Algorithm.

lead us to solve this complication .

First of all, with the help of horizontal, vertical, or canny edge algorithms we extract the edges from the image. Symmetry is ought to find out in these edge image input. Fig. 2.4 edge image can be used to extract symmetry under an extreme condition. Furthermore, no edges are extracted in the uniform areas.

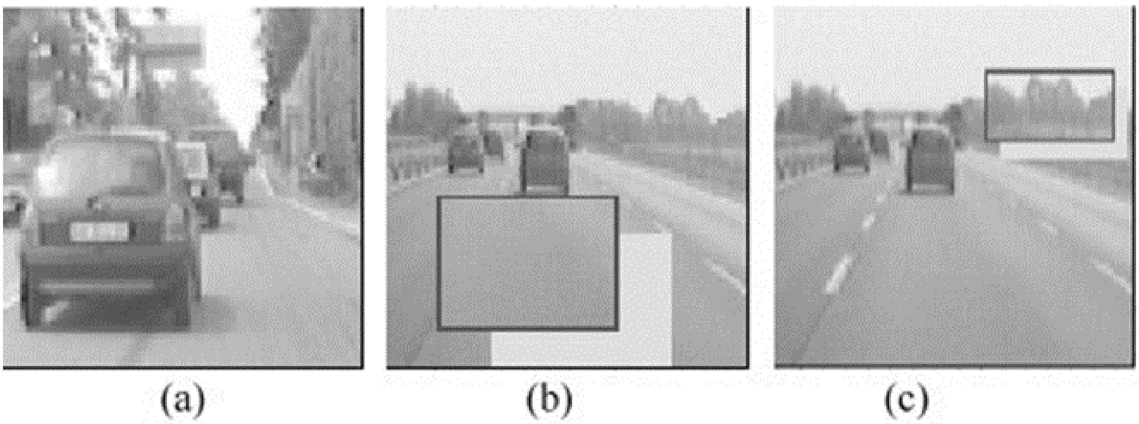

Figure 2.4: (a) Strong reflection, (b) Uniform area, and (c) Background pattern are the cause of irregularities in vehicle symmetry.

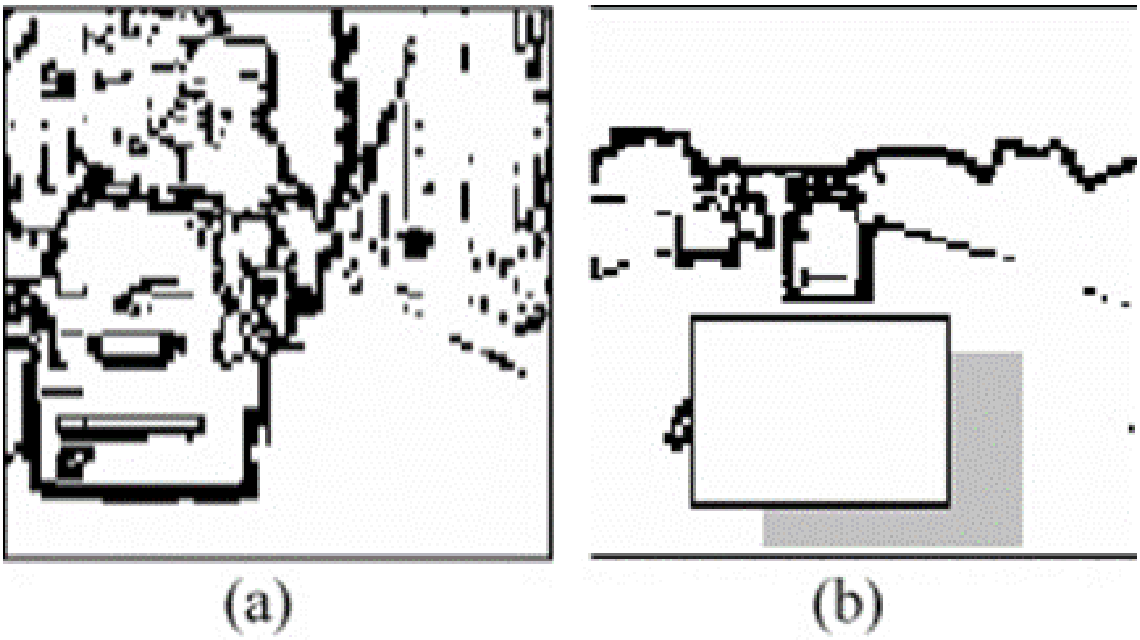

Figure 2.5: (a) Projections, and (b) Filtered projections.

we qre goinf to solve this issue by compute symmetries in binary picture. At first, edges are extracted by using canny edge algorithm to get rid of unwanted edges [13] in an image. Symmetries are computed in these edge images. Fig. 2.4 shows that yet a strong reflective body is existed on the left side of the car, edges can be visible and it coulde be used to extract symmetries of the car; moreover, in consistent areas, edges are are not extracted and thereby symmetries can not be detected.

2.5 Horizontal and Vertical Projection

For a given binary image its Vertical and horizontal projection of in put image are calculated by using Equations 2.8 and 2.9. In Figure 2.6..a, 2.6..b, and 2.6..c a raw binary image, horizontal and vertical projection are presented. In our ALPR system we implemented both of the projections for segmenting license plate. Each of these projections **24** has separate task. For example,

$$f_h\,(i) = \sum_{j=1}^{W} BI(i,j) \tag{2.8}$$

$$f_v\,(i) = \sum_{i=1}^{H} BI(i,j) \tag{2.9}$$

horizontal projection is used for separating the rows which comprises reg. info. On the other hand, for segmenting digit and character [4] vertical projection is used.This threshold can transform in accordance to the input image and performance as a result it acts as a result it is very flexible.

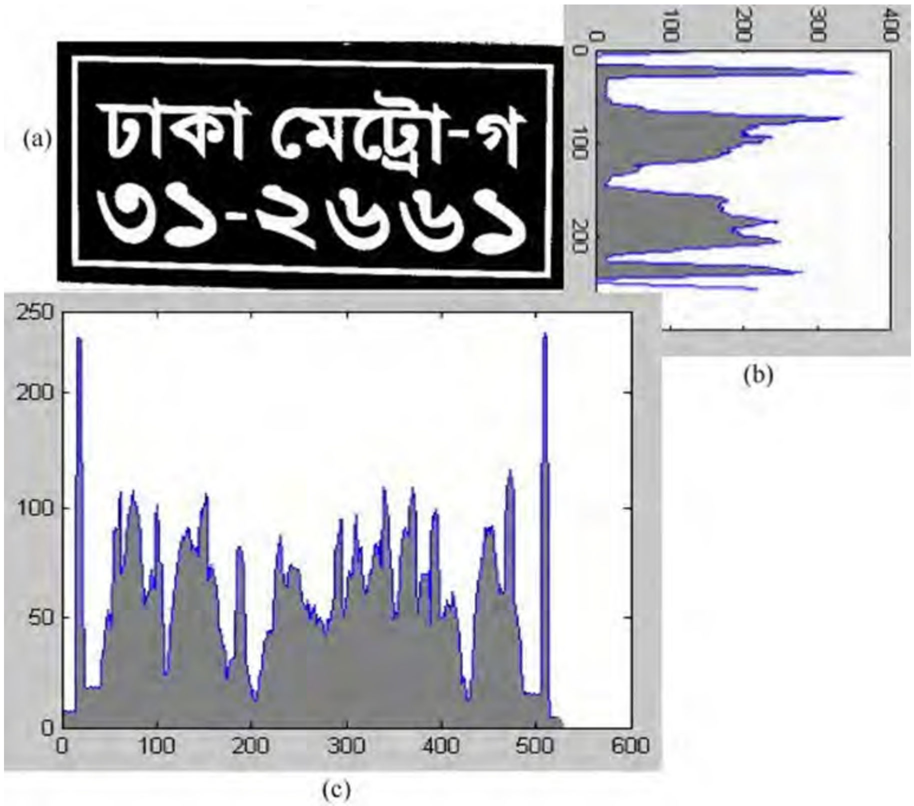

Figure 2.6: (a) Original license plate image, (b) Horizontal projection, and (c) Vertical projection.

2.6 Moving Average Filter

Running average filter is also known as Moving average filter. It is used to soften data by reducing the effects of random variation in data. Removal of short-term fluctuations and high frequency components from data set is its primary goal. It is also used as the low pass filter in digital signal processing. Moving averages can be achieved by calculating mean of the set of numbers belonging to 1st window. After that new average is calculated and window is moved ahead to the data [25] and over the entire data set this process is repeated. The moving averages is the line which connects all the averages. Application of the filter determines value of parameter W where high value of Results in long-term trend of data set. After that reduction of short-term fluctuations is performed. Among various moving average filters Simple moving average filter is used by us which is described below.By using the following formula, a simple moving average (SMA) is evaluated from a given date set X: x1, x2, x3, · · ·, xn.

$$SMA\,(i) = \sum_{k=1}^{k=W} x_{i-k} \tag{2.10}$$

Simple Moving Average
In this equation i ¿W. Moreover, in Fig. 2.7(a) and 2.7(b) Sample projections and filtered projections are shown respectively. The horizontal and the vertical projections evaluation was performed for separating the rows and segmenting the characters and

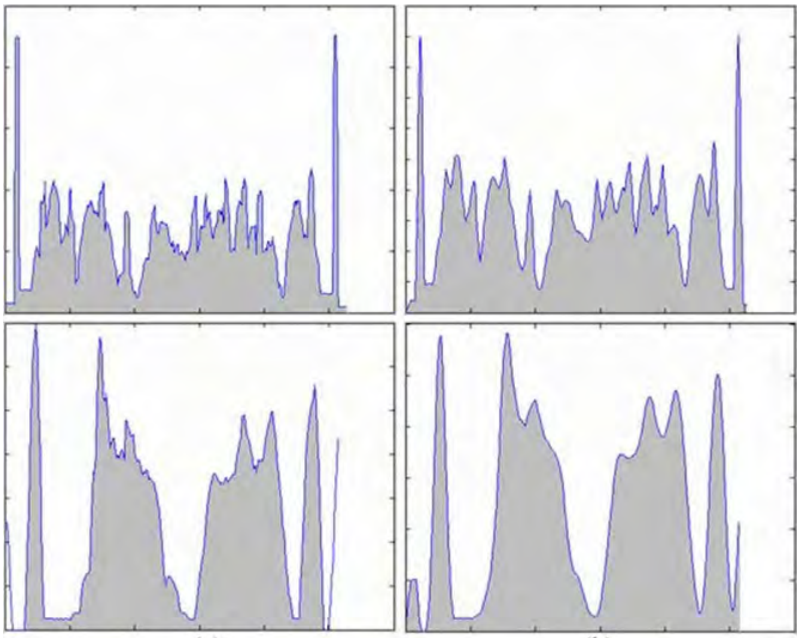

Figure 2.7: (a) Projections, and (b) Filtered projections.

digits respectively in the license plate segmentation stage. The characters or digits and the rows was represented by [14] local maxima of vertical and horizontal projections. Since, unwanted local maxima and minima exists in these projections so the elimination is performed by using Simple Moving Average (SMA) filter. Due to suppleness along with same weight for each member value in the projections Simple Moving Average (SMA) filter is used.

2.7 Extrema Detection

Extrema is [16] a mathematical term. In a function extrema is the combination of maxima and minima. In other word, extrema is that particular point in a function which gives highest or lowest value. Extrema is categorized in two particular types. One is Local Extrema and another one is known as Global Extrema.
Local extrema is again a combination of local maxima and local minima. The idea regarding local maxima and local minima can help in understanding the concept of local extrema. Local maxima is a point in which the function value is greater than the nearby neighborhood point. Again Local minima is a point in which the function value is lesser than the nearby neighborhood points. So local extrema can be defined as: in a function it is a particular position within the neighborhood range where it returns the maximum or minimum value. It is also known as Relative Maxima.

On the other hand, global extrema consist of global maxima and global minima. Global maxima is that point, where function value is greater that that of all other points regardless of respective position. And Global minima is that point, where function value is lesser that that of all other points regardless of respective position. So global extrema is the position in entire domain where it returns largest or the smallest value **34**. Every horizontal and vertical projection indicates a row of license

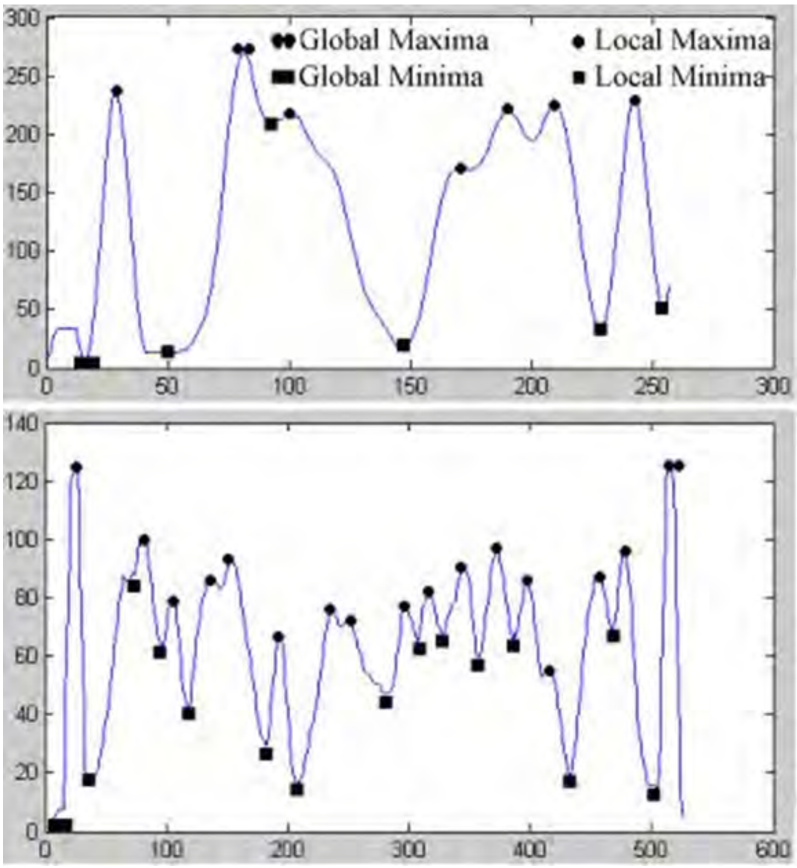

Figure 2.8: Extrema Detection

plate. It also present character. In order to find out the local maxima extrema detection method is followed.

2.8 Artificial Neural Networks

Numerous mathematical models have been designed for different purpose. ANN model is one of the widely used model among them. ANN stands for Artificial Neural Network. This model is based on the intra-network of nuron cells in our brain. Nurons are designed to perform particular task with unique set of structures categorized in layer. A group of nurons works together. ANN is a system that can turn out to be very complicated since it is trained to change its structure depending on the information providing through it. [11] There are many applications of Neural Network. For example : Classification, pattern matching, image processing, including and many more.. Artificial Neural Network is split in two parts - recurrent or Feedback and Feed-Forward or acyclic network. Feed-Forwarding approach can detect characters and digits. It exist in non circular form as the units are connected in certain way. Here signals passes from one layer to the others without any delay or pause. Three types of feed-forward network are present. All of These networks have particular set of pros and cons. In neural networking [24]systems learning process is very important. It is a logical process by which the performance of the system can be developed. There are many rules regarding learning process such as, delta learning rule, oustar learning rule etc.

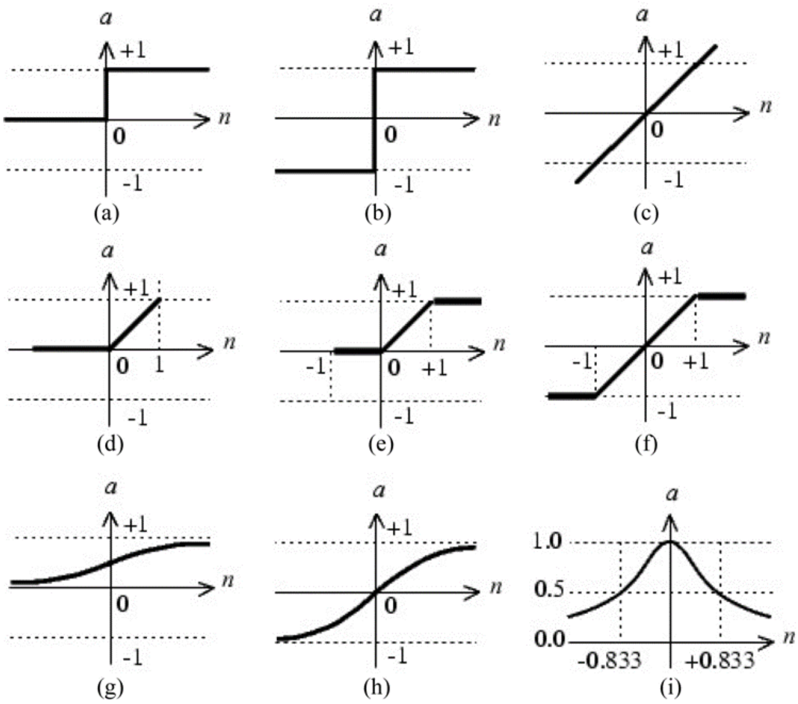

Figure 2.9: Activation functions: (a)Hard limit, (b) Symmetric hard limit, (c) Pure linear, (d) Positive linear, (e) Saturating linear, (f) Symmetric saturating linear,(g) Log sigmoid, (h) Tan sigmoid, and (i) Radial basis.

2.8.1 Activation Functions

Activation functions [22] are responsible for defining the behavior of neuron or a processing unit. Different Activation functions exists which can be categorized in following manner:
Threshold: Depending on the particular size of input threshold value output become set one of two levels. For example, symmetric hard and hard limit belongs to this activation function which are illustrated in figure 2.9(a), 2.9(b).

Linear: Inputs of total weighted activation functions for example positive linear, symmetric saturating linear, pure linear, saturating linear are proportional to linear activation function and these are illustrated in figure 2.9..c, 2.9..d, 2.9..e, 2.9..f

Sigmoid: Although input change is linear but output change is not linear. For example, tan sigmoid, log sigmoid, radial basis belongs to this activation function and they are illustrated in figure 2.9(g), 2.9(h), 2.9(i) accordingly.
We applied pure linear and log sigmoid activation functions in both output layers and hidden layers.

2.9 Summary

We elaborately discussed multiple approach consisting several algorithms in this chapter. We use and Canny edge, horizontal and vertical detection algorithms have been used for detecting edge. Symmetry algorithm accomplish the task of locating vehicle on the image. In the segmentation part a combined approach were used where vertical and horizontal projections are implemented along accompanied by extrema detection. Lastly, for the digit and character recognition, feedforward network was our choice.

Chapter 3

Literature Review

3.1 Introduction

For the most part, license plate acknowledgment calculations of an ALPR framework are made out of a few stages, for example, location, division and acknowledgment of tags. Many procedures have been built for these referenced stages attributable to having colossal execution of license plate acknowledgment. In this part, we depict a short diagram of a review of various procedures that are used in these stages during the time spent for the acknowledgement of the license plate.

3.2 Algorithms for Detecting License Plate

Firstly, the ALPR framework decide which area of license plate will be used for the information picture and how it can be an actual picture or a video succession which could be a paired, dim scale or a shading picture. Thus, these referenced preparing frameworks to be specific, double or dark scale, are utilized in this stage.

3.2.1 License Plate Detection Algorithms Using Image Processing

There are a number of parallel picture preparing strategies, for example, associated component investigation [29], edge insights and morphological examination **6**, [23], [33] and spatial estimation [29] are the notable and broadly utilized techniques

Edge Statistics and Analysis
There are a few exploration tasks **6**, [23], [33] where edge of measurements and numerical morphology were utilized. The adjustment in brilliance in the license plate territory is way incessant contrasted with different pieces of plate which has been used as significant property to find tag. This cycle registers the slope greatness and the neighborhood fluctuation of edges of a picture. Along these lines, license plates are separated depending on the high greatness of the slope and the change. In any case, while it goes to a complex a picture containing complex foundation, radiator **8** of the vehicle and so on can depict a high difference of brilliance along these lines numerical morphology, for example, disintegration, expansion and so forth furthermore, edge measurements are utilized together to take care of this issue with respect

to lit up territory of the tag.

Connected Component Analysis
One of the essential strategies in twofold picture preparing is Connected component analysis (CCA) [29]. By checking a parallel picture, it marks its pixels into segments based on pixel availability. When it decides all the gatherings, every single pixel is named with a value dependent on the segments to which it was allotted. There are a few double items, for example, size, perspective proportion, direction and so on To ascertain essential estimations of those double items, it utilizes separating and naming of a few disjoints and associated segments in a picture. In the division stage, CCA can eliminate all commotions and undesirable articles separated from the characters and digits from the double permit picture to make this cycle immaculate.

Spatial Measurement
To find the license plate in a picture, spatial estimations for instance, zone, direction and Aspect Ration (AR) are broadly utilized in paired handling calculations [29]. To channel license plate territories, these rules are applied and these zones are parallel articles undoubtedly. Along these lines, those objects of double items, for example, direction, region, and angle proportion will be dispensed with on the off chance that they don't fall into a substantial reach. Extraordinarily, viewpoints proportion is utilized to discover the area of tag.

3.2.2 Processing using Grey Scale

A lot of examination studies[24], [27], [28] have utilized dim scale handling methods, for example, picture change **14**, district division [27], [28], edge checking [34] and square based [24] to discover the area of tag.

Image Transformation
This strategy has been fiercely used to distinguish license plates which are powerful in discovering straight lines or edges in the information picture that involve the fringe of the tag. Gabor channels **14**, combined with spatial estimations, are applied to find the tag. Thusly, thee channels have gotten tremendous consideration in record of the recurrence and direction portrayals of human visual framework can be handily assessed by these channels. Gabor channels have numerous applications, for example, surface division, report examination, target location, edge discovery, retina recognizable proof, picture coding, etc. Notwithstanding, this cycle is extreme com putationally and languid for picture with enormous examination. Separated these channels, Hough Transform (HT) **4** is likewise used to identify license plate limit. The Hough Trans development, an element extraction method, is applied to search for defective cases of articles with an assistance of a democratic system.

Region Segmentation
Sliding Concentric Windows (SCW) is a versatile picture division procedure which is utilized to identify license plates in [27]. The SCW strategy was set up dependent on nearby qualities, for example mean fluctuation of a picture. Sizes such as x1 x x2 and also x2 x y2 of A and B windows are utilized. The detail portrayal is given in segment 3.5.1.

Edge Counting
An examination paper [34] utilized a license plate restriction strategy created nervous tallying. In this strategy, it checks the N-line separation of a picture to tally the edges where this system expects the presence of a license plate if the edge number is more prominent than the limit esteem. In the event of not finding the plate, the calculation is run again with the declined edge esteem. Nonetheless, this strategy can't find the license plate in complex situations alongside certain cons.

Block Based
Some examination works [24] utilized Block-based scale preparing strategy for license plate recognition. In this technique, it partitions input picture into several blocks where blocks containing edges of high fluctuation or high greatness is considered as the likely license plate zone. Nonetheless, some mathematical measures, for instance viewpoint proportion and territory are likewise used to distinguish blocks as genuine license plates since all the discovered squares are not license plate regions. The implantation cycle is simple in this technique as it doesn't rely upon the license plate edges, henceforth it can be petitioned to a muddled limit of license plate picture. Notwithstanding, it neglects to identify the license plate while picture foundation is mind boggling.

3.2.3 Distinct Algorithms for License Plate Detection

There are many exploration works who utilized shading preparing[21], [36] and fluffy set hypothesis[9], [12] other than paired and dim level handling.

Color Processing
For writing the license plate and its identification proposals of Numerous calculations [21], [36] have been made. Imperative thought of discovery utilizing shading preparing is the shading mix of plate and its character which are extraordinary which is generally found in the license plate locale region. This shading mix is checked by pixel-by-pixel to identify the license plate area. In any case, there are some impending purposes of shading handling, for example, if shading is insecure due to various enlightenment, it might cause variety in discovery.

Fuzzy Set Theory
We have found of utilizing Fuzzy rationale in the writing to find the license plate [12], where the writers clarified the accompanying natural principles concerning the vision of license plate by human: 1) It is an object of brilliant rectangular territories comprising of dull zones, for example, digits and characters where the fringes are nearly more splendid than its environmental factors. 2) It is found mostly in center and sometimes in the lower part of the center of a picture. 3) The element of the license plate is around 530 x 120 mm. There are a few stages of executing this strategy as it works. Most importantly, the info picture is re-sized to 786 x 576 and afterward parceled into sub pictures of size 75 x 25 pixels. As per natural standards, it processes a wellness esteem for each parceled sub picture in the wake of dividing

the picture where an apportioned sub picture holding the greatest wellness esteem is considered as the tag. The calculation falls off finding the license plate 97 pictures out of 100 pictures as the creator referenced. Notwithstanding, this calculation may not be viable for a lot of irregular info tests in light of area and separation of license plate imperatives.

3.3 Character Segmentation Algorithms

In the subsequent stage segmentation of the characters and also the digits take place. For this situation, both parallel and dark scale picture preparing methods are applied for division of the characters.

3.3.1 Segmentation Algorithms

For division reasons vertical and horizontal projections [26], [36] as well as morphology of numbers **20** which are some methods for processing of image are utilized.

Projections
The flat and vertical projections of the pixels are generally utilized and the simplest strategy to fragment characters [26], [36]. Ordinarily, projections are figured with the assistance of a parallel picture tag. There are a few conditions for the two of them where the projection made horizontally is applied to differentiate the lines and the role of the projection made vertically is to separate the digits and letters of that particular line.

Mathematical Morphology
Examination work **19** utilized a character division calculation dependent on numerical morphology. They clarified a versatile methodology for corrupted plate pictures. By utilizing morphological activities, for example thickening and pruning, they alleviated the clamors subsequent to changing the license plate into a twofold picture. The motivation behind thickening activity is to distinguish fringes between covering the characters for tidying up irrelevant articles in the thickened picture. Once, eliminating commotions is done, the vertical projection is processed and it looks for the division focused on the projection contrasted with least qualities. Therefore, it might have the option to partition the characters into numerous fragments and some of them may be embedded into a picture. They pick if the combining of pieces is essential by using the previous data of the best measure of areas and the widening of a character. Basically, they isolated covering or related items, if central.

3.3.2 Grey Scale for Character Segregation

For preparing scale of dark color, there are many broadly utilized strategies, for example, nearby and versatile edges [13], [19], histogram handling **23**, **29** and classifiers [4], [10].

Nearby and Adaptive
This technique depends on changing over a greyscale license plate picture into a twofold picture. This change should be possible by using worldwide and close by sift olds. An overall edge based binarization strategy is used that is Otsu's binarization figuring. Pixels with regard over this limit are named white and all different pixels are delegated dim. Nevertheless, binarization with an overall edge doesn't constantly make capable outcomes due to non uniform light very surprising pieces of the license plate picture. Binarization uses the neighborhood to meet the needs of non-uniform light. Neighborhood edge-based binarization procedures are of two types. For essential kind of neighborhood binarization technique, a picture is isolated first in squares of m n, cutoff points also processed pieces individually. For the case of second system of binarization every pixel edges are registered. White color is delegated for the pixel if it is regarded over the breaking point. Something different it is named dim. Re search work [13] uses such a local binarization technique in license plate division compose.

Classifiers
Disguised Markov secures are utilized to show a stochastic relationship between a data picture and the differentiating character division. A division technique of character was proposed by Franc and Hlavac **34** for loud less-objective tag pictures, where the division issue was granted as the most silly a posteriori appraisal from a ton of satisfactory divisions. The framework relied upon misusing from the previous information, for instance, the destined count of letters in the plate and its equivalent the underlying speculation with (yet dim) directed width. The quantifiable model was delivered as it was given by a client by utilizing an arranging plates of Czech division portrayals.

3.3.3 Bangla OCR Character Segregation

Bangla OCR has a fundamental part which is the division of the characters. Three undeniable levels are used for the division which include the division processes of word, line and character [15], [22], [37]. Data picture is checked for line division and dull pixels are rehashed in each push and is added as to fabricate the histogram of push. Zero respect in the histogram represents the cutoff between the lines. The lines are then moved for the division of words after the division of lines is completed. Different dull pixels in each fragment are resolved to make segment histograms. The aspect of the line with consistent dull pixels is seen as a word in that line. On the off chance that in channel of vertical no faint pixel is found to be considered as word dissipation.
A push histogram picks up the circumstance of matra while segmenting the words in co-ordination. Circumstance of matra is shown most by the raised recurrent of the push. Characters are seperated after the matras are removed. The isolated characters are then parted by vertically checking the straight and piecewise.
Notwithstanding, key level checking isn't palatable enough to divide lines of the tag. Since the arrangement of the Bangla tags shifts from each other. A few tags have a breaking point, a couple have an even line between the segments, and a couple contain additional data other than enlistment zone, sort, and number. These

arrangements [2], [17], [27] make it stunning to disengaged segments using major level filtering. The circumstances of matra in OCR is navigated by the proper usage of the push which utilizes the pixels by the outrageous rehash. Likewise, cancellation of the horizontal line which is the matra assists in fragmenting characters where there is matra present and the segmentation is done into many pieces which are different from each other. The victory of this Matra retraction approach amazingly depends upon the skewness region and change assessments.

3.4 Algorithms for Recognizing Plates

Character affirmation stage is the third and the last masterminding of an ALPR framework. Neural structures of several kinds, for instance, Covered up Markov Show (Well) **29** machine algorithm like Support Vector Machine (SVM) [20], and also Fake Neural Arrange algorithm (ANN) [9], [14], [17], [34] are generally applied for the task of recognizing. Model or setup arranging methods [8], [25] are also used for viewing the letters.

Support Vector Machine
A method that learns to separate information and also sees the and comprehends the plan is an support vector machine (SVM).For assessment of backslide and plan SVM is used. In Korean award plates Back Vector Machine (SVM) is used to view the characters. Four bits of the plate such as upper and lower characters and also the upper and lower numbers were viewed using the framework where four base character recognizers were used.

Convolutional Neural Networks
To view the characters and digits of the tag Multi-layer neural systems which uses the feed-forward technique have been utilized. Old style arranging procedure is back-expansion [31] which prepares the calculations for the feed-forwarding system of neural network. Compose must be prepared for different preparing cycles to accomplish an unbelievable confirmation rate over dim test information. Additionally, the amount of layers which are covered, neuron amount inside the hidden layers lastly, the authorization limits is picked by an experimentation method to accomplish an ideal result.

3.5 Other Different Case Studies

A heap of assessment works has been coordinated to make a convincing ALPR system as a result of various executions. Almost all ALPR structure created subject to arrangement of specific nation or a state's tag. Three ALPR structures **4**, [28], [32] from unquestionable areas in unassuming segments have been discussed here. English, Vietnamese, and Bangla award plates freely were viewed using the ALPR framework.

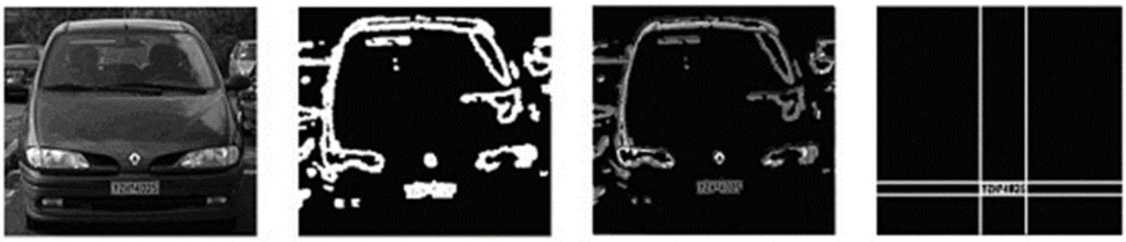

Figure 3.1: Segmentation process of license plate: (a) Original image of vehicle, (b) Result of SCW after segmentation, (c) Logical AND operation image, and (d) Detected License Plate

3.5.1 Automatic License Plate Recognition System for English License Plates

An assessment work [28] of Anagnostopoulos et al. displayed a tag cooling knowledgement structure framed in English. They develop a computation which is Sliding Concentric Windows (SCW) that uses the sudden changes inside the neighborhood picture to select an award plate which is present. The computation utilizes picture encounters, for instance, standard deviation and mean a motivation to depict the near to oddities inside the picture.Concentric windows such as A and B which are of different size is used by this count. The sizes are x1 x y1 and x2 x y2. As the sizes are different so x2 ¿ x1 and y2 ¿ y1. At the basic pixel of the picture the windows are made to be centered there. Enlisted windows has faint pixels and there standard deviation and mean features are mentioned there as well.
Cutoff T if is outperformed by standard deviation and also mean characteristics inside achievement rows outperforms cutoff T then differentiating windows pixel which are concentric is respected with having a spot to a tag. They channel the picture from left to legitimately similarly as from best to foot utilizing these two windows in genius to sort out which parts of the picture have a spot to a tag. The limits X1;X2; Y1; Y2; and T are described by the customer consenting to the particular application and perspective extent of the license plate.
Result of SCW count is a matched picture containing contender tag locale. A predictable AND movement is finished between this twofold picture and the fundamental picture. The found picture is set to binarize with the help of the Sauvola locally adaptable binarization figuring. Related Component Examination (CCA) is additionally used to perceive related territories in this twofold picture. A region is recognized as the liberal tag reliant mainly on size, point degree, introduction, and also the Euler number. The principle picture as well as the differentiating picture undergoing utilization of estimation of SCW, also the logical operation of AND is also performed which results independently. Inside the tag division stage, the oversaw tag picture is re sized to 75 288 pixels utilizing bi cubic associate from the information and with the taking after father boundaries: x1=3; y1=8; x2=6; y2=16; and T=0:7, standard deviation is calculated at each window's faint pixels. Ensuing to changing the resultant picture, matched things are named utilizing CCA. The statures and the bearings of these twofold things are surveyed. The articles whose evaluation don't satisfy explicit shows, for instance, heading ¿ 75o and tallness ¿ 32 pixels are killed. The remainder of the things are isolated by discovering the

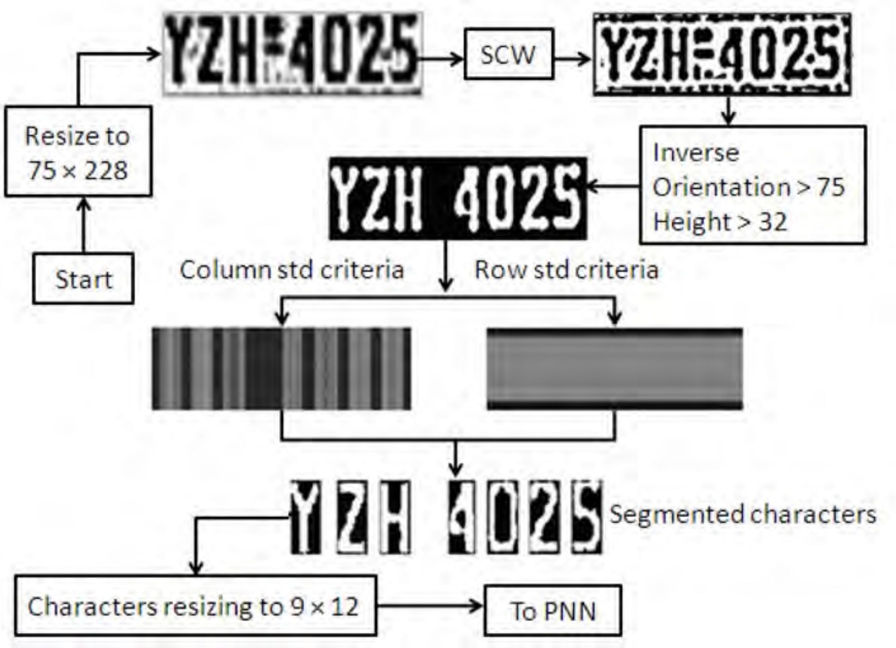

Figure 3.2: Segmentation process of license plate in a flowchart [28].

standard deviations of the characteristics in the lines and the portions of the tag picture. Most non standard deviations are used because on it division bases are dependent. 912 pixels is the size to which the characters and digits are re-sized to. 108-180-36 is the neural make of this geology. Data layer includes focus which is of 108 amount of focuses standing out from input vector (108 =9 x 12). 108 focus focuses and 36 center points are present in the center. Guided arranging set is used by PNN to make dispersing limits inside a model layer. These cutoff points, inside the review mode, are utilized to gauge the probability of a data include vector being a fragment of an academic characterization or course. Figure 3.3 depicts the idea of PNN.

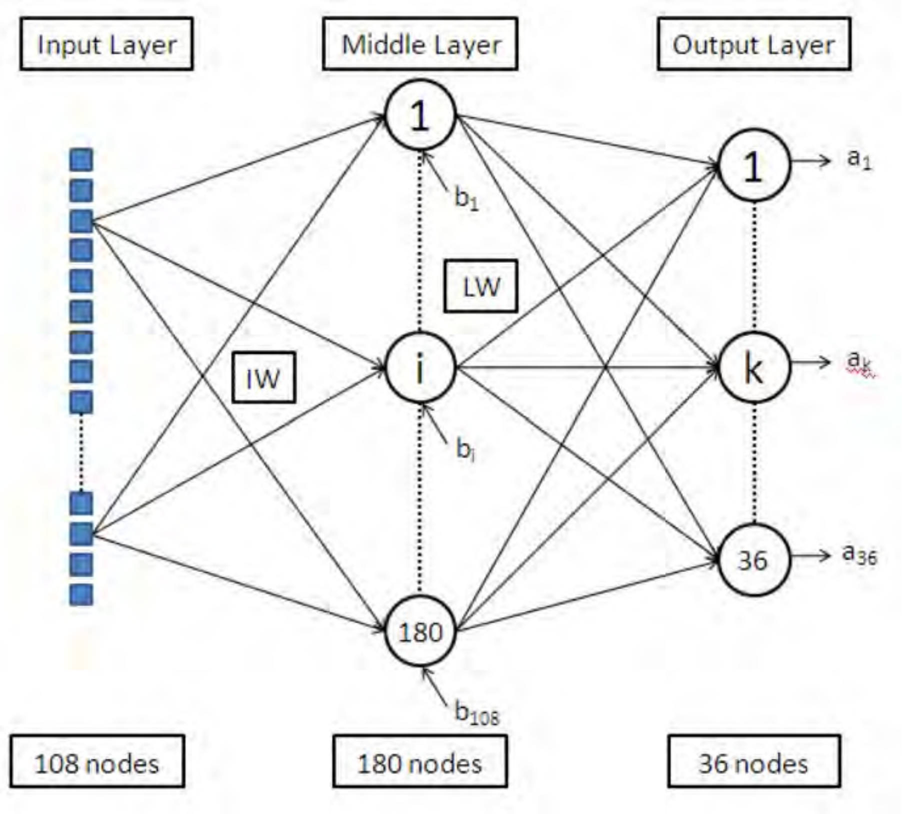

Figure 3.3: Architecture of the PNN [28].

A smoothed result is energized after primer and blunder is used on the SCW figuring portrays the edge T. Places where the lighting of the photographs are obvious this procedure would most likely not be optimal solution to solve the problem. Pictures having distinctive light conditions may fail to pass as a limit that performs well with a great deal of pictures. Being developed, the SCW may misleadingly recognize many tag areas in a picture having an incredible foundation with various astounding changes. Particular technique does not pass spectacularly in segregating the characters in Bangla. At first isolation of characters and digits are done into 12 x 9 and then they are re sized. And this is very small when considered against the Bangla characters.

3.5.2 An ALPR system for Vietnamese LP

Vietnamese tag made in English can be seen in **4** which is a affirmation count for changed vehicle tag. To discover the structure lines edge picture is derived from the image of the data which is found in the tag region. Two lines that consolidate the tag constraint is found out using the Hough change.
In the event that these lines don't take after the even plane, turn change is related with adjusting them to a straight point. Several candidate equivalent lines are picked as the imaginable tag areas that meet the necessities of a pre demonstrated connect of viewpoint extents. Two level crosscuts are utilized over the up-and-comer territories and starting there forward, the amount of things that are cut by these crosscuts is checked.If amount of cut things is inside of the extent of the characters in tag then it is considered as a award plate namely up and comer.

(a)

Plate-candidates	Number of objects	Result
	2	Non-plate
	2	Non-plate
53M-4893	10	Plate
52T 7013	4	Plate

(b)

Figure 3.4: Detection stage of license plate **4**: (a) Hough trasnform and contours Detection of candidate license plate, and (b) Validation of candidate license plate.

ietnamese tags may have two lines which are compared to Bangla labels. They detached these two lines by utilizing a level projection. The spots of insignificant assessments of level projection are utilized as the beginning stage or the completion of a line inside the tag. To allocate the characters which are needed for a push a vertical projection is used then and then. Scrutinizing the characters' division cycle is rethought of. Seven or eight characters are present in the Vietnamese tag. Hidden Markov Demonstrate (HMM) in the first stages for the digit and character recognition is utilized. 50 pixels is considered as the size for scaling the pictures of the characters. 196 characters are merged using a join vector. From this time forward, the data layer of the Well has 196 focus focuses. The yield layer has 36 focus focuses, diverging from 26 characters and 10 digits. The tag division course of action is appeared in Fig. 3.5(a), and 3.5(b).
In case the vehicle is excessively unavailable from the camera, characters inside the tag won't be obviously undeniable. Subsequently, it'll not be conceivable to discover the amount of characters accurately by the level crosscut.Even though the system for Vietnamese license plate does not make any mistakes in the vertical projection but when applied in Bangla characters it misfires as the use of matras hamper this process.
In case the vehicle is as well distant from the camera, characters inside the license plate will not be clearly obvious. Thus, it'll not be conceivable to discover the number of characters precisely by the flat crosscut. In spite of the fact that their straightforward vertical projection viably sections characters in Vietnamese permit plates, it fails with the Bangla characters in Bangladeshi license plates due to the nearness of the Matra at the top of the foremost of the Bangla words in Bangladeshi license plates.

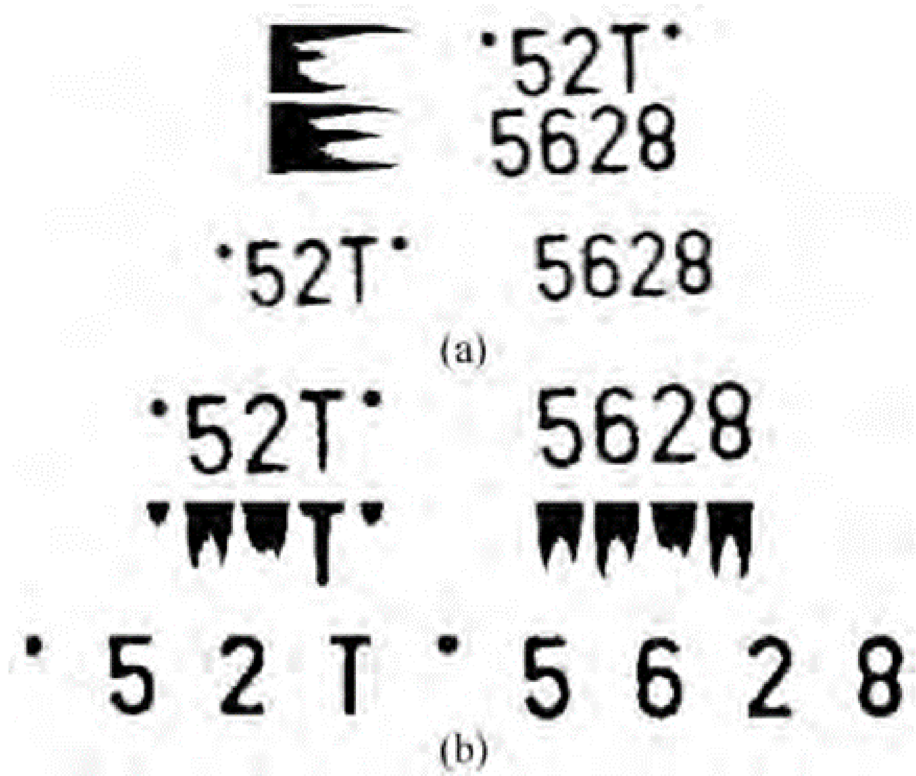

Figure 3.5: Segmentation phase of license plate**4**: (a) Horizontal projection row segregation, and (b) Vertical projection character segregation.

3.5.3 Automatic License Plate Recognition System for Bangla License Plates

Bangla tag with license plate which are customized and the structure is affirmation is mentioned in [32]. In the structure equivalent to other people the use of phases of division, proof and affirmation is viewed. By following a distinct partition the images taken were amazingly snapped. The territory of the tag is trimmed using rules that were already assessed such as the measure and circumstance of the tag. Pixel by pixel plan in the tag picture is used to find the data which has been enlisted. Disjoint districts in the tag picture oversaw was found out by executing a portion assessment. Neural association for a four layer back induce is used to view the digits. 128 neurons make up the data and covered layers while 10 neurons are present in the yield layer. Figures 3.6(a), 3.6(b), 3.6(c), 3.6(d), and 3.6(e) depict the tag territory and division phases autonomously. Several bona fide deficiencies are present in this model. They ignored the basic line of the tag inside and out. The basic line contains data on vehicle enlistment region and sort. Enrollment zone and type data can't be ignored. Furthermore, the circumstance of the vehicle inside the data picture was utilized to discover the tag. This framework capacities honorably metaphorically representing their game plan of data pictures anyway comes up short for a theoretical course of action of data pictures. Also, their monster power approach to manage looking through the enlistment data is time-eating up. Inside the resulting stage, they separated disjoint digits by related portion evaluation which can't appropriate joint Bangla characters.

Figure 3.6: (a) First picture, (b) Empirical crop result, (c) Brute force and scanning result, (d) Registration plate with only the lower half, and (e)Extraction of individual characters.

3.6 Summary

To sum up, an outline of the current procedures in three periods of ALPR systems has been spoken to. Equal picture preparing, greyscale picture taking care of, concealing picture planning, and cushy set theory have been utilized to recognize tag. Related fragment examination, Hough change, morphology of numbers and also, Gabor channel, corner locator, etc are utilized near to evaluations, for instance, an area, bearing, and perspective extent to find the labels. From different equal and greyscale pictures dealing with techniques, projections and related portion assessment were primarily used to area the labels. Sponsorship vec apex machines, arranged sorts of neural structures, and design planning were utilized for getting the characters and also the digits of the labels in the third stage.The scheme that was suggested by us for the ALPR framework for Bangla language, the utilization of algorithms such as CCA, edge finder, spatial evolution also morphology of number and many more has been used.To ensure quality so that the Bangla language can be perceived properly and better understanding of the characters and digits feed forwarding process of the neural network has been used which is of multi layer and has botch back-inducing learning figure. We have also depicted in this part three ALPR systems from around the world along with the drawbacks of why it cant be implemented for Bangla language with achieving the utmost results. Even though the systems of ALPR for English and Vietnamese is very efficient and can perceive the tags yet their tags are not suitable for the computational execution of Bangla language and the ALPR framework for Bangla language that has been presented does not have sufficient tag for self- definitive information picture. Inside the Bangla award plate all the characters and digits can not be conveyed as its divisional computation is not made for it.

Chapter 4

Proposed Scheme

4.1 Introduction

Different Automatic License Plate Recognition System are already developed in order to recognize license plates. Some of the ALPR systems we discussed earlier which were developed for recognizing English, Chinese and Bengali license plates have certain limitations in terms of some constraints and provides a very poor performance while recognizing Bengali license plates. To get good performance a robust ALPR system is required for Bengali license plate. We present a robust and highly effective Automatic Bengali License Plate Recognition system inside this chapter. ALPR system proposed by us has three different stages which includes license plate detection, characters and digits segmentation and characters and digits recognition. We develop and use existing algorithms in each stage to provide a robust ALPR system for Bengali license plates which is discussed in subsequent parts.

4.2 Detection of License Plate:

4.2.1 Introduction

We will be talking about the approach how we detected the license from the vehicles that previously detected from an image. There are many different ALPR systems that have been described in the literature view. In most of the cases ALPR systems have been developed to detect mostly English license plates. In this segment we propose a new detection method for Bengali license plates using some existing algorithms.

4.2.2 Vehicle Detection

To detect a vehicle from an image we are going to use Symmetry algorithm. Property of symmetry [35] was 1st implemented for vehicle detection on the streets. Symmetry is a very common characteristic in realistic and almost all types of vehicles that we on the roads possess those characteristics. Suppose, we watch a vehicle from the rear side, it will be vertically symmetric. If an image contains more than one vehicle, then it will have multiple vertical axis of symmetry.

Generally, the symmetry score of a point is calculated by the operator by the summation of the absolute differences in pixel values that are equal but in totally opposite directions from the center of symmetry point. This function is usually performed over a symmetry window in a predefined size of an image. The search window size is difficult because it will affect the area of the detected symmetry axis and the size of the symmetric objects that can be optimally detected. Basically, this size is detected to match the size of a vehicle in the input image.

Algorithm: Symmetry detection algorithm

$h \leftarrow$ Height of the image
$w \leftarrow$ Width of the image
$wh \leftarrow$ round $(\frac{3}{4}h)$ Height of the symmetry window
$ww \leftarrow$ round $(\frac{3}{4}w)$ Width of the symmetry window
$SM \leftarrow$ new Matrix (wh, ww); Symmetry Matrix
for $c \leftarrow ww/2$ to $w - ww/2$ **do**
for $r \leftarrow h/8$ to $7h/8$ **do**
$v \leftarrow 0$;
for $k \leftarrow 1$ to $ww/2$ **do**
$v \leftarrow v +$ abs (Image $(r.c - k)$ + Image $(r.c + k)$)
end for
$SM\ (r - h/8 + 1, c - ww/2 + 1) \leftarrow v$;
end for
end for

4.2.3 Convert the image into Grayscale

We utilize the trimmed pictures recently handled to distinguish a vehicle from the info picture. From the start, we recovered the shading picture to a grayscale design utilizing the COLOR.BGR2GRAY technique in light of the fact that grayscale pictures are anything but difficult to track down the edges of the pictures and all the more significantly our calculation needn't bother with shading data. Changing over a hued picture into grayscale is an extremely muddled strategy with striking features.The structure, differences, sharpness and shadow of a hued picture can be lost while changing over it into grayscale. Another calculation has been proposed to save the differences, shadow, structure and sharpness of the hued picture. Here the proposed calculation plays out a few executions like RGB estimate, expansion of luminance, decrease and expansion of chrominance. The created grayscale picture utilizing the calculation that we are utilizing in this examination ensures that the calculation is saving the remarkable features(contrasts, sharpness, shadow and structure) of the hued picture. The steps from 1,2 and 3 calculate the luminance and chrominance values of the input color image. In step number 4 the summation of chrominance is calculated. From the step number 5 to 16, the RGB values using the approximated RGB components. Finally, the last step estimates the mean value of the four values R4, G4, B4and UV. Figure 4.2.3 represents resulted gray color image.

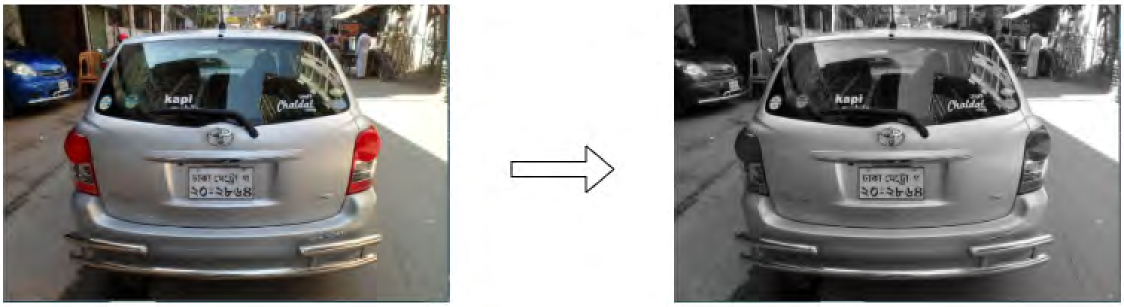

Figure 4.1: Converting Color image to grayscale

Algorithm: Grayscale Algorithm

$$
\begin{aligned}
&START\\
&\quad Y \leftarrow (0.299xR) + (0.587xG) + (0.114xB);\\
&\quad U \leftarrow (B - Y)\, x0.565;\\
&\quad V \leftarrow (R - Y)\, x0.713;\\
&\quad UV \leftarrow U + V;\\
&\quad R1 \leftarrow R * 0.299;\\
&\quad R2 \leftarrow R * 0.587;\\
&\quad R3 \leftarrow R * 0.114;\\
&\quad G1 \leftarrow G * 0.299;\\
&\quad G2 \leftarrow G * 0.587;\\
&\quad G3 \leftarrow G * 0.114;\\
&\quad B1 \leftarrow B * 0.299;\\
&\quad B2 \leftarrow B * 0.587;\\
&\quad B3 \leftarrow B * 0.114;\\
&\quad R4 \leftarrow (R1 + R2 + R3)/3;\\
&\quad I1 \leftarrow (R4 + G4 + B4 + UV)/4;\\
&END
\end{aligned}
$$

4.2.4 Noise Cancellation

In the second step we will smoothen the picture by playing out a commotion abrogation strategy. For this situation we utilized Bilateral Filter **50** to smoothen the picture. Two-sided sifting deletes undesirable edges of the pictures and ensures just anticipated edges, by social affair a nonlinear mix of nearer pixel esteems. The referenced strategy is basic, neighborhood and non iterative. In view of both their mathematical volume and their photometric comparability, it coordinates tones and will in general pick the close to qualities to remove qualities in both x and y pivot or space and reach. In lieu of standard separating, respective sifting decreases ghost colors where they show up in the first picture and delivers no shades of apparition along edges in shading pictures.

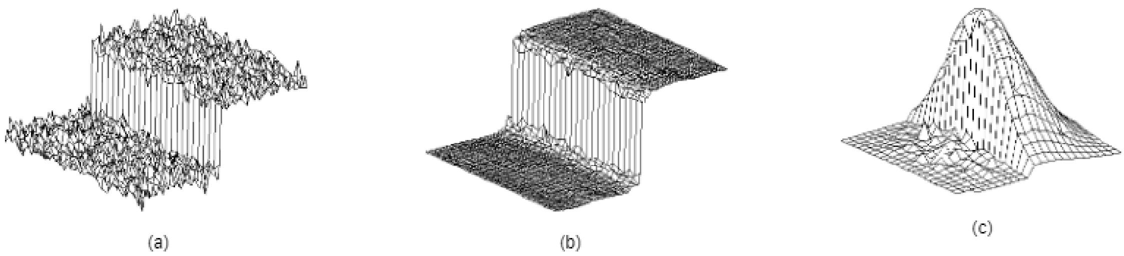

Figure 4.2: Boundary between a dark and a brighter area

The Idea
The underlying thought of respective calculation **50** is to play out the sifting in the info picture that past customary channels couldn't do in the specific reach. Two pixels could be close to one another, that is, include near to territory, or they might resemble one another, that is, have near to values, maybe in a perceptually huge style. First envision a move invariant low-pass space channel that is applied to a picture:
$\boldsymbol{h}(x) = k_d^{-1}(x) \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \boldsymbol{f}(\xi) c(\xi, x) \boldsymbol{d\xi}$
The f and h speak to the stuff that both information and yield pictures might be multi-band. So as to secure the DC part, it could be composed as
$k_d(x) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} c(\xi, x) \boldsymbol{d\xi}$
Range filtering can be written as:
$\boldsymbol{h}(x) = k_r^{-1}(x) \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \boldsymbol{f}(\xi) s(f(\xi), f(x)) \boldsymbol{d\xi}$
In this specific case, the portion recognizes the photometric likeness between pixels. The standardization steady for commotion wiping out in this condition is
$k_r(x) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} s(f(\xi), f(x)) \boldsymbol{d\xi}$
The arrangement is to consolidate space and reach sifting, and afterward authorizing both mathematical and photometric aerials. Consolidated filterung can be portrayed as follows:
$\boldsymbol{h}(x) = k^{-1}(x) \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \boldsymbol{f}(\xi) c(\xi, x) s(f(\xi), f(x)) \boldsymbol{d\xi}$
with the normalization
$k(x) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} c(\xi, x) s(f(\xi), f(x)) \boldsymbol{d\xi}$
The last come about space and reach will be demonstrated as Bilateral Filtering. It set back the pixel esteem at x with a normal of the equivalent and closer pixel estimations of the picture. In smooth zones. Pixel estimations of a little neighborhood are the equivalent to one another and the reciprocal channel responds as an ordinary space channel, averaging ceaselessly the little, feebly related contrasts between pixel esteems brought about by commotion. Envision now a honed limit between a dull and a more brilliant region, as in figure 4.2(a).
At the point when the reciprocal channel is focused, envision a pixel on the splendid side of the outskirt and the comparative capacity expects values are near one for pixels on a similar side, and qualities almost zero for pixels on the clouded side. Focusing the two pixels to one side of the progression that is in figure 4.2(a) is upheld by the capacity that appears in figure 4.2(b). The standardization term k(x) guarantees us that the loads for all the pixels signify just one. Thus, the channel replaces the brilliant pixel at the middle situation by a normal of the splendid pixels, and basically overlooks the dim pixels. Alternately, the splendid pixels are disregarded when the channel is focused on a dull pixel. In this way, as appeared in

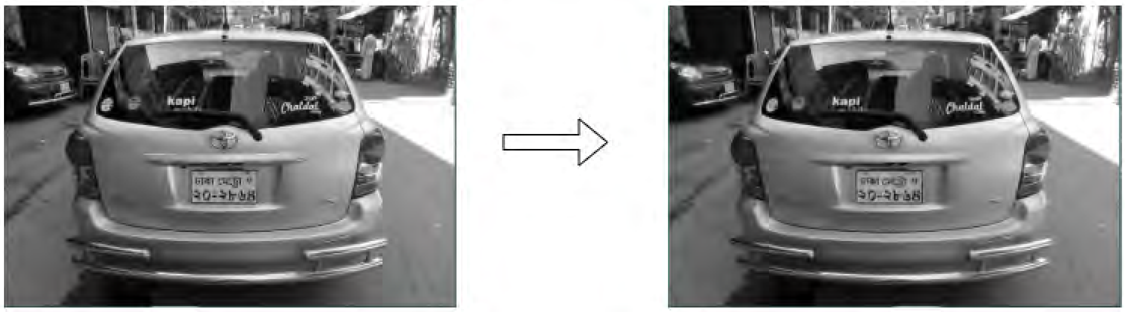

Figure 4.3: Smoothing grayscale image

figure 4.2(c), great separating conduct is accomplished at the outskirts, fresh edges are protected simultaneously once, on account of the scopes of the segment.

4.2.5 Find Edge

In this section we will discover the edges of the smoothened picture. To play out this assignment we have utilized the 'Vigilant Edge' **50** calculation to discover the edges of the picture. We are leading this calculation on a smoothened picture on the grounds that a smoothened picture eliminates the undesirable edges from the picture thus it is simpler to locate the normal edges in a picture.
Vigilant Edge Detection is the most mainstream among all other edge identification calculations. It was created by John F. Vigilant in 1986. Since edge location is relied upon the measure of commotions in a picture, the initial step is to eliminate clamors utilizing Bilateral channel. We have just smoothened pictures in the past advance.

Gradient Calculation
The edge force and bearing is distinguished by the Gradient figuring venture by ascertaining the slope of the picture utilizing edge identification administrators. Applying channels that feature this force change in both flat (x) and vertical (y) bearings is the simpler method to identify the power. At the point when the picture is performed through the calculation, let the subsidiaries I_x and I_x w.r.t. x and y are determined. It very well may be actualized by convolving I with Sobel bits **8** K_x and K_y, individually:

$$Kx = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}, Ky = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}, Kz = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}$$

Then, the magnitude $\boldsymbol{G}$ and the slope θ of the gradient are calculated as follow:

$$|G| = \sqrt{I_x^2 + I_y^2},$$

$$\theta(x, y) = arctan(\frac{I_y}{I_x})$$

The outcome is nearly what we expected, however it appears to be a portion of the edges are slight and some are thick. A Non-Max Suppression step can take care of

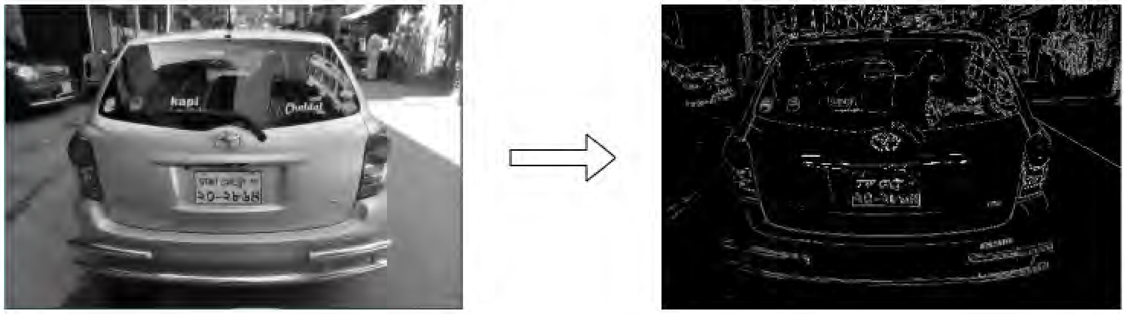

Figure 4.4: Find Edges of the car

this issue. Be that as it may, we have not gone further to this. Also, the inclination power level of the tones in the picture is somewhere in the range of 0 and 255 which isn't uniform.

4.2.6 Find and Draw Contours

Forms can be clarified essentially as a direct bend that joins all the consistent focuses (along the limit), having a similar tone or force. The forms are helpful instruments for shape examination and item discovery and acknowledgment if there should arise an occurrence of profound learning.
In this progression we will discover forms on the edges that we discovered in the past section utilizing 'Topological investigation of paired pictures by fringe following' [3]. In the wake of finding the forms we will draw the shapes on the first picture with a graphical tone.
Following the outskirts is the most major strategy to handle a twofold picture. It infers a succession of the directions or the chain codes from the outskirt between an associated part of 1-pixels (1-segment)' and an associated segment of 0-pixels (foundation or opening). Since the outskirt following method has a huge assortment of utilizations, including picture acknowledgment, picture investigation, and picture information pressure, it has been concentrated profoundly. The motivation behind this portion is to distinguish the rectangular tag on the vehicle.
Subsequent to finding the forms of the edges we drew all shapes with a RGB shade of (0,255,0) which is light green in graphical view. To draw the shapes we utilized Python 'drawContours' calculation. It can likewise be utilized to draw any shape that was given limit focuses.

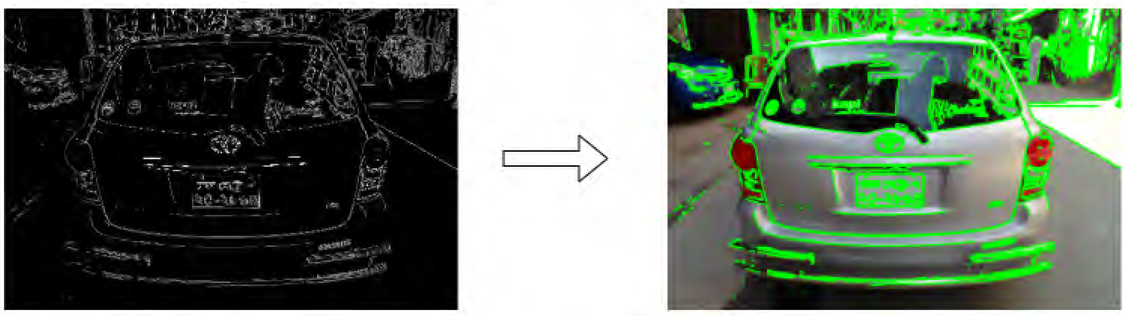

Figure 4.5: Finding and drawing contours of the edges

4.2.7 Sort Contours

In this consecutive fragment we arranged the forms dependent on their region keeping the least required zone as '30'. Anything smaller than '30' will not be considered in the list. To perform this job we used the 'contourArea' algorithm to find out the area(in pixel) of the contours.

Parameters:
Contour – Input vector of form vertices, put away in vector.
Oriented – Oriented territory banner. In the event that it is valid, contingent upon the direction of forms, the capacity restores a marked territory esteem. Utilizing this component you can decide the direction of a form by taking the indication of a region of pictures. As a matter of course, the boundary is bogus, which implies that the supreme worth is returned in reality.
The capacity processes a form of territory. In this manner, on the off chance that we draw the shape utilizing drawContours(), the returned zone and the quantity of non-zero pixels, can be unique. Additionally, definitely the capacity gives wrong outcomes for the yield forms with the self-convergence component.

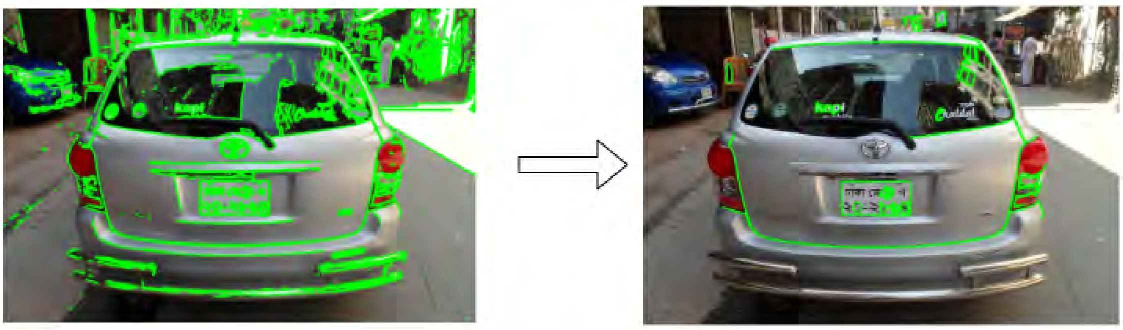

Figure 4.6: Sorting contours keeping minimum area as 30 pixels

4.2.8 Detect License Plate

In this segment we are going to detect the license plate depending on the corners of each contour of the image. As we know if we imagine a raw car there is only one component which has a shape of perfect four corners and that is the License plate. No other component outside the car has exact perfection of four corners. Even the glasses of a car have some curved shapes which differ from our methodology. So if we find out the contours with perfect four contours, that is the license plate. The Pseudocode for the methodology that we developed is given below:

Algorithm 2: finding actual rectangular method

for each contours of the image
detect the perimeter of the closed contour
detect the number of corners
if the number is 4 then this approximate license plate
find coordinates of the of the corners
crop the image and save it
end for

Figure 4.7: Detecting License Plate

Figure 4.8: Cropping License plate from image

4.2.9 Convert the image into Grayscale twice

We utilize the edited pictures recently prepared to distinguish a tag from the information picture once more. To begin with, we convert the shading picture into a grayscale picture utilizing COLOR.BGR2GRAY strategy on the grounds that grayscale pictures are obligatory to play out the binarization cycle. Changing over the shading picture into grayscale requires the picture the COLOR.BGR2GRAY calculation seek after RGB estimation, decrease, and expansion among chrominance and luminance of the picture. The grayscale pictures are created utilizing the COLOR.BGR2GRAY calculation in the trial affirms that the calculation that we utilized has protected some huge highlights of the shading picture, for example, contrasts, sharpness, shadow, and picture structure.

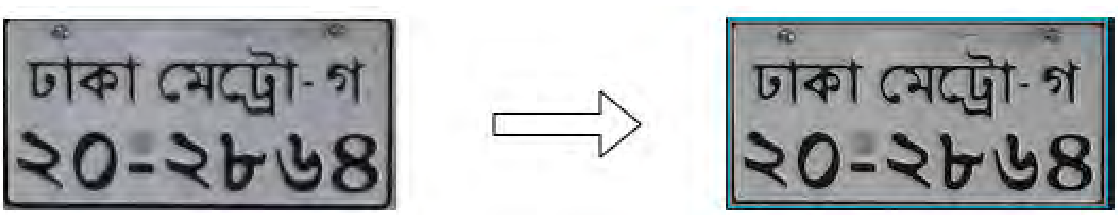

Figure 4.9: Converting Color image to grayscale

4.2.10 Binarization

In this section we are going to binarize the trimmed tag picture. Which implies the picture will have just two tones: dark (0,0,0) and white(255,255,255). In this portion we will utilize Otsu's binarization technique [1]. Otsu's binarization strategy [1] chooses an ideal limit for a given picture by augmenting a basis, i.e., the detachability of the resultant classes in dim levels. It expects that the dark degree of the given information picture runs in 0, 1, 2, . . . , L 1, where L is the all out number of dim degrees of the picture that the client input. Contingent upon the level L the OTSU's calculation changes over the pixel in black or white. We have additionally played out something else that is if the measure of dark is more prominent than white, we convert dark pixels to white and white to dark. There is a critical motivation to play out this capacity. Some of the time we can see a portion of the foundation tones are not dark by any stretch of the imagination. Exceptionally the old transports and vehicles outside Dhaka city have this situation. For this situation the letters are in white and the foundation tone is white. As we utilized convolutional organizations to identify characters, it possibly works when the letters are in dark text styles. Along these lines, If the strategy finds that the foundation is in dark and the text style tone is white, naturally it will change the shading.

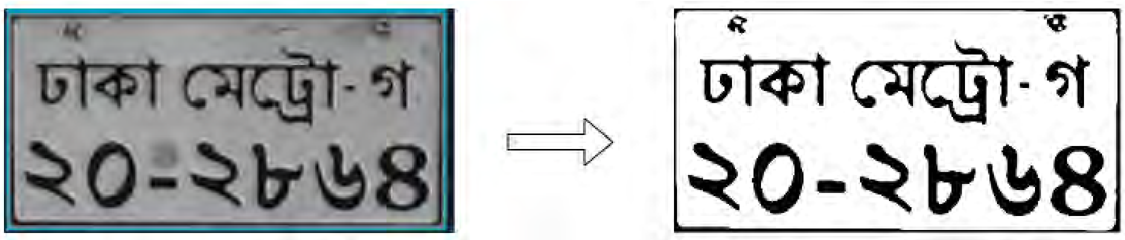

Figure 4.10: Binarization of the image

Here is a histogram of the level of white and black color in the image that we used. X axis indicates amount of color and Y axis indicates color where 0 is black and 255 is white.

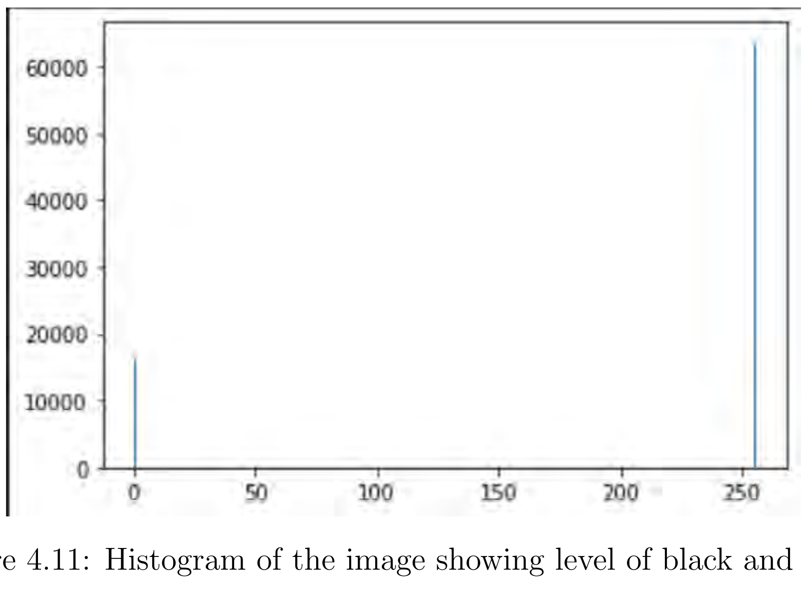

Figure 4.11: Histogram of the image showing level of black and white

4.3 Segmentation Of License Plate

Due to various complexities Bangla characters segmentation in Bengali License plate is very difficult. So, to overcome these difficulties a special algorithm is being used which uses vertical and horizontal projections with adaptive threshold for segmenting Bangla characters and digits properly. To segment license plates a lot of research work has been done [9,18,19] based on projection. Adaptive threshold used by us keeps changing according to the input image along with the segmentation output. Moreover, it can segment Bangla characters. Overall segmentation procedure comprised of multiple stages. Firstly, row separation is performed that contains license plate information. Finally, we perform segmentation of characters and digits.

4.3.1 Row Separation

To separate the rows, the binary image of extracted license plate which contains registration information of the vehicle will be used as input image but it may contain some noises such as unnecessary dots, boundary in other words run away pixels which might affect the segmentation process badly so to make the whole segmentation process better we eliminate those noises in the binary image by detecting the connected regions. Then after measuring the connected regions area elimination of all smaller regions which contains area fewer than a threshold is performed.

$$f_h\left(i\right) = \sum_{j=1}^{col} LP(i,j) \tag{4.1}$$

$$f_h\left(i\right) = \begin{cases} f_h\left(i\right), ift \leq W \\ \frac{1}{w}\sum_{k=1}^{W} f_h(i-k),\, Otherwise \end{cases} \tag{4.2}$$

$$y_h = Average(LocalMinima(f_{h1}\left(i\right)) \tag{4.3}$$

Now we perform row separation after elimination of noise from the binary image. First of all, evaluation of the horizontal projection of the binary image is performed by using equation 4.3.1. After that we filter resultant horizontal projection function fh(i) by applying equation 4.3.2 which refers to the Moving average filter where window size of the Moving average filter is W as it may contain some unwanted local minima or maxima. fh1(i) is produced from fh(i) by this filtering function which contains convex arches and each of these rows refers to a particular row of the license plate. Arches which belongs to fh1(i) found by local maxima enumeration but in case of attached arches, they are separated by upward shifting of the x-axis using yh parameter. Using equation 4.3.3 we perform the calculation of yh . After that largest two arches which represents two rows containing registration information of Bengali license plate are selected based on the area covered by them.
In figure 4.2 and 4.3 we illustrate the extraction process of rows of the license plate described earlier. A very simple license plate containing only two rows shown in Fig. 4.2(a). Moreover, filtered horizontal projection fh1(i) is illustrated in figure 4.2(b) and figure 4.2(c) which contains two arches. But the license plate image in figure 4.3(a) is more complex than image shown in figure 4.2(a) because it includes more than two rows. In figure 4.3(b) we show resultant horizontal projection fh(i) again.

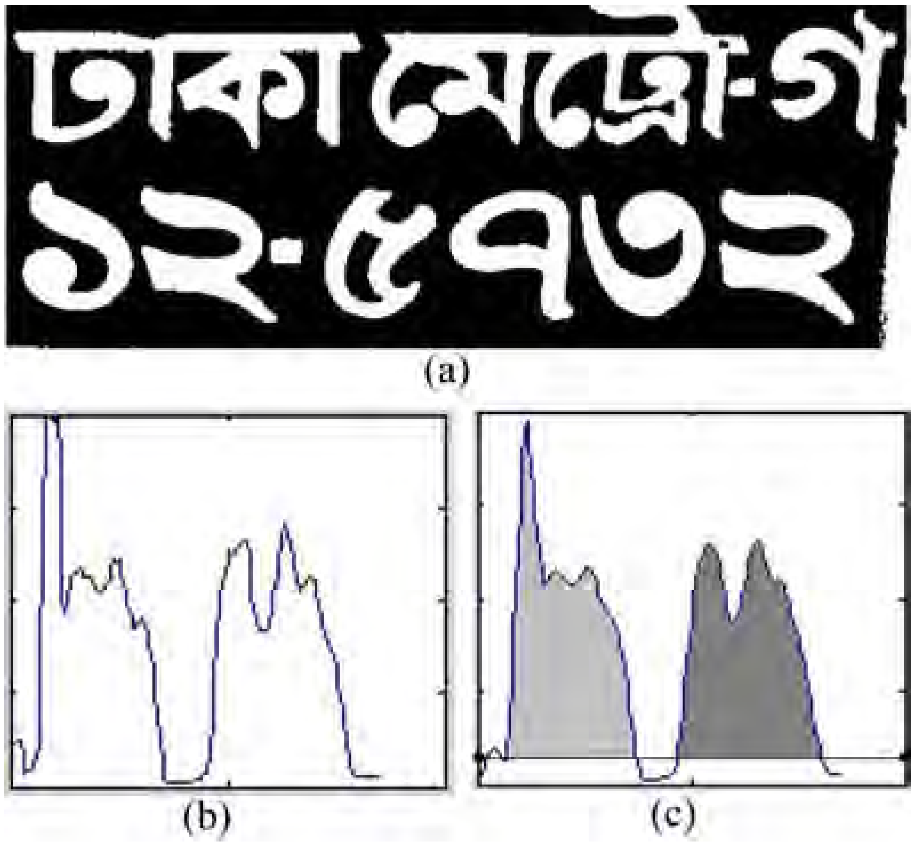

Figure 4.12: Outputs of simple license plate License segmentation stage. (a) Binary image of a simple license plate, (b) Horizontal projection of the pixels, and (c) Filtered projection.

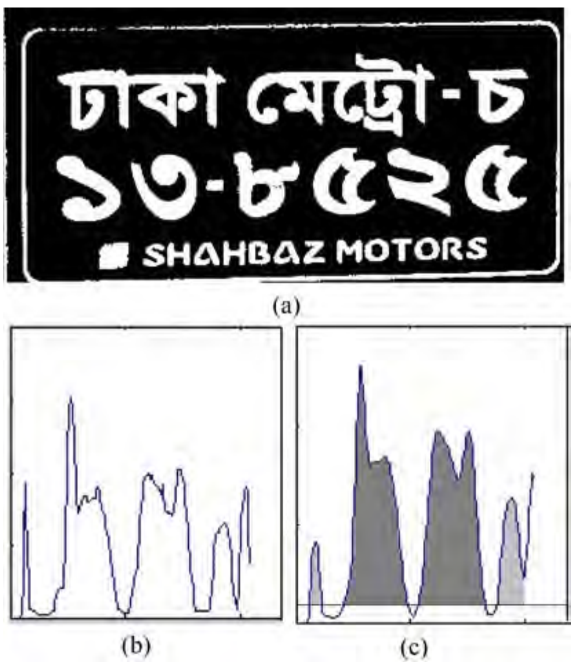

Figure 4.13: Outputs of simple license plate License segmentation stage. (a) Binary image of a simple license plate, (b) Horizontal projection of the pixels, and (c) Filtered projection.

Figure 4.3(c) represents filtered horizontal projection fh1(i) containing five arches where five rows are corresponded. In figure 4.3(c) overlaid horizontal line is shown which refers to evaluated threshold. Largest two arches are considered according to the area covered by them which represents 2 rows which contains vehicle registration information.

4.3.2 Characters and Digits Segmentation

Matras at the top makes the segmentation process of the first row very complex and tricky so in order to perform segmentation of Bengali characters in first row we use segmentation with adaptive threshold (SAT) algorithm because according to its performance and the input image it adapts itself for segmenting the characters. But threshold value is very important because lower threshold merge multiple characters into one and threshold with high value divides character into more than one segments. The numbers of characters without Matra in Bangla alphabet is eight. Firstly, the threshold value (Tint) is set to the half of Matras width. When Tint value is high multiple segments creation is done from these characters on the other hand low value of Tint makes the segmentation process slower. For Tint computation evaluation of horizontal projection fp(i) of the first row containing Bangla characters is done. After that we filter it to acquire function fp1(i). fh1(i), fh(i) in equation 4.1 and 4.2 are similar to fp(i) and fp1(i) respectively. In comparison to the neighborhood pixels number in Matras region is more high. As a result, corresponding to these regions portion of fp1(i) we become steeper in compare to its neighborhood so Tint is set to the half of the steeper portion. Computation of extent of the steeper potion is done in several stages. After evaluating derivative fp11(i) of function fp1(i) by applying equation 4.4 all the minima, maxima which belongs to fp1(i) is listed. In order to select sequence of positive numbers and a maximum number of fp11(i) , we try to find out the sequence of numbers between minimum and maximum in fp11(i) is done by us and finally Tint is set to the length of the sequence. The first row and second row of the license plate are illustrated in figure 4.4 (a) and 4.4 (b) along with that by figure 4.4 (c) we show Tint by overlaid vertical lines of two and the extent of the steeper portion. We start segmenting the characters after Tint value is set and evaluation of vertical projection fv(i) of the binary image which contains first row of the license plate is done by applying equation 4.5. But fv(i) might contain some unnecessary local minima and local maxima so by filtering fv(i) these unnecessary minima and maxima is required. Moving average filter which creates new function fv1(i) used for filtering is shown in equation 4.6.

$$f^1{}_{p1}\left(i\right) = \frac{1}{3}\sum_{x=1}^{3}\left|f_{p1}\left(i-x\right) - f_{p1}\left(i+x\right)\right| \tag{4.4}$$

$$f_v\left(i\right) = \sum_{i=1}^{row} LP(i,j) \tag{4.5}$$

$$f_{v1}\left(i\right) = \begin{cases} f_v\left(i\right) ift \leq W \\ \frac{1}{w}\sum_{k=1}^{W} f_v\left(i-k\right), Otherwise \end{cases} \tag{4.6}$$

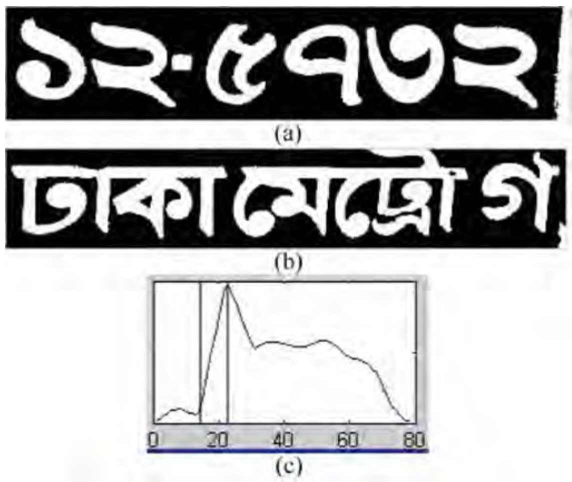

Figure 4.14: Threshold initialization step: (a) Separated row containing digits, (b) Separated row containing characters, and (c) Calculating initial threshold.

We show in figure 4.13 (a) and 4.13 (b) and 4.13 (c) first row of license plate along with (fv(i)) and (fv1(i)).

Convex arches in fv1(i) is equal in number to the characters available in the first row of the license plate. Separation is performed by upward sliding of x axis equal to Tint amount if connection exist among convex arches, which results in segmentation of some characters or not based on value of Tint. By edge counting in segmented part determination of complete or incomplete segmentation is done. Horizontal projection across the middle of the Bangla characters contains equal or less than four edges and complete segmentation can only be assumed if less than or equal to four edges is present in segmented portion but segmented portion containing more than four edges can be assumed as incomplete segmentation. As a result, if segmented part contains more than for edges incrementation of the value of Tint along with repetition is performed until the segmentation process is complete. Segmentation of digits is performed by evaluating the vertical projection fd(i) of binary image which contains digits after that filtering is required so that we can get the function fd1(i) . fv(i) and fv1(i) are similar in compare to fd(i) and fd1(i) shown in equation 4.5 and 4.6. Amount of digits included in 2nd row of the license plate is equal to the convex arches available in fd1(i) . The arches are separated by x-axis as there is no joint among the digits in the license plate. Considering non-ideal circumstances when the license plate contains various noises, separation of the arches is performed by the alignment of the x-axis upward along with maintaining equality in terms of Td amount where the cropped license plate image defines Td magnitude. Graphical representation of segmentation with adaptive threshold algorithm is shown in figure 4.6. According to figure 4.6(a) we get the function with four separated parts by applying Tint to the function fv1(i). Moreover, in figure 4.6(b) overlaid horizontal line and resultant of four segments of the characters are shown and segments contains four, eight, twelve respectively. While counting edges the holes inside the characters are ignored. The segmentation of first and fourth segments characters can be counted as complete as they both contain four edges but we do not need to segment second and third segment characters as they contain more than four edges.

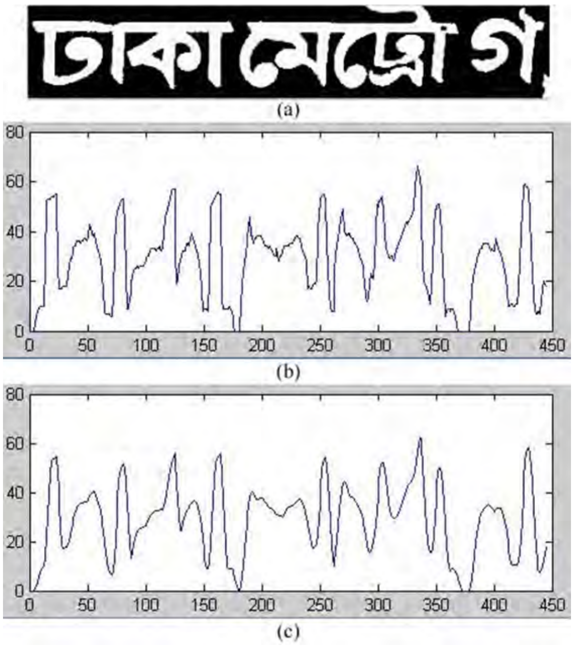

Figure 4.15: Segmenting characters: (a) Binary image containing characters, (b) Vertical projection of the pixel, and (c) Filtered vertical projection.

After that the Tint value is increased which is shown in figure 4.6(c) in order to complete these segmentations. We get new seven segments from two previous segments by application of the new threshold and in figure 4.6(d) it is illustrated. Among the seven segment five segments is considered as complete because the number of edges is equal or less than four. Until there is one character left in last segment this process is being repeated again and again. In figure 4.7(a)-digit segmentation is shown. Digit segmentation is easier in comparison to character segmentation as there is no connection by Matra. For digit segmentation vertical projection is taken shown in figure 4.7(b) where constant threshold is used to separate resultant arches. Finally, we illustrate the segmented arches in figure 4.7(c).

4.4 Characters Classification

In this section we discuss how the extracted characters and digits of the license plate are classified using Artificial Neural Network (ANN). Among different types of ANN, a feed forward back- propagation network is used because of its efficiency, simplicity and robust performance [31]. The overall classification process consists of multiple steps which are feature extraction, resizing the image of characters and digits, network architecture design, features normalization, feeding unknown data to test the network. All of these steps are described elaborately in the subsequent sections.

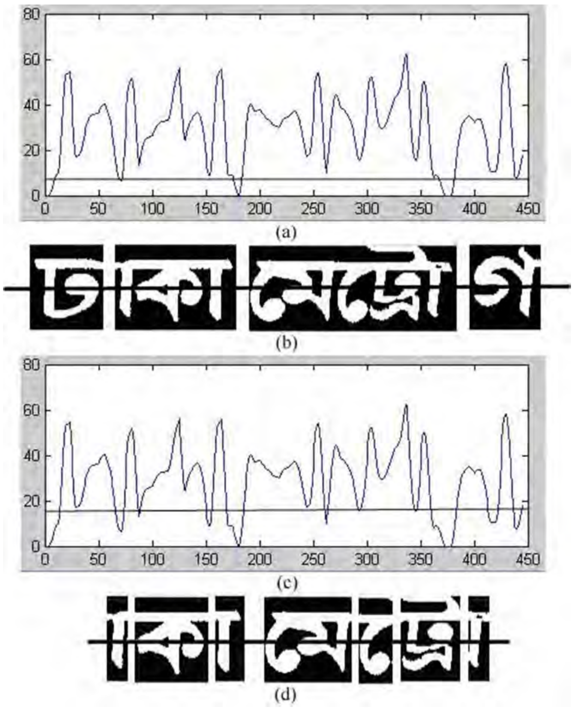

Figure 4.16: Segmenting characters

4.4.1 Feature extraction

Extracted digits and characters can have different sizes as a result for our convenience before using them as the input to ANN we scale up or down the images of characters and digits into 32 × 32 image. In order to reduce noise during images resizing 'Bicubic interpolation' is used. A feature set is extracted in order to train the ANN. Firstly, the vertical projection of the image is taken which produces a vector of size 32 where the value is between 0 to 32 for each element. After that each element is divided by 32 to normalize this vector which makes the value of each element in the vector between 0 to 1. By taking the horizontal projection of the image we get another vector of size 32. After that we get a single vector of size 64 by merging these two vectors of size 32. Finally, we use this vector as the input to the ANN. In figure 4.8 and 4.9 we show some characters and digits classification training samples.

4.4.2 Network design

Two different ANN is used to classify the first-row characters and second row digits of the license plate. Input layer of both of the neural network is of size 64 as the input vector is 64 in size. For digit classification as we have to recognize ten different digits neural network should contain 10 neurons in the output layer similarly for character classification output layer should contain twenty-five neurons because not all the characters of Bangla alphabet are being used in license plate. According to our observation only twenty-five characters are widely used in license plates as a result we will focus only on these characters. In output neurons we use pure linear transfer function which is shown in figure 2.9(c). Neural network will be trained by various network architectures by applying some variance in the hidden layer's numbers, hidden layers neurons, network training functions and transfer functions

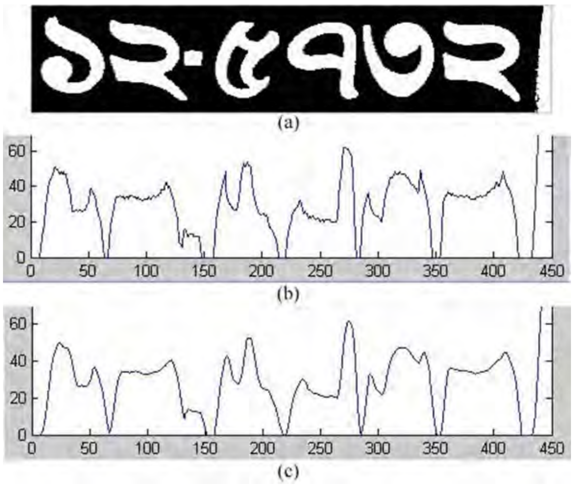

Figure 4.17: Segmenting digits: (a) Binary image containing digits, (b) Vertical projection of the pixel, and (c) Filtered horizontal projection.

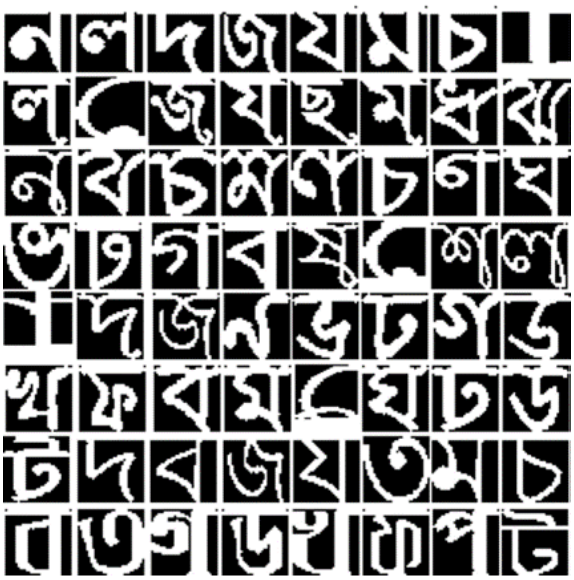

Figure 4.18: Some training samples for the character classifier neural network.

so that it can be suitable for recognizing Bangla digits in the license plate. After that recognition success rate is recorder by simulating the network using test data. After broad experimentation, we see that a three-layer network containing sixteen and thirty-two neurons in 1st and 2nd hidden layers individually can recognize the Bangla digits effectively.

According to our observation from the experiment we conducted in comparison to tan sigmoid, log sigmoid transfer function shows better performance for unknown test data. Moreover, in comparison to Gradient Descent Adaptive back-propagation (GDA) [31], Scaled Conjugate gradient with back propagation (SCG) [6] and One Step Secant back-propagation (LM) [5] the convergence rate of Levenberg Marquardt back propagation (LM) [7] is higher but OSS back propagation algorithm shows better performance than other propagation algorithms as a result for our training function we use OSS back propagation algorithm to achieve a robust sys-

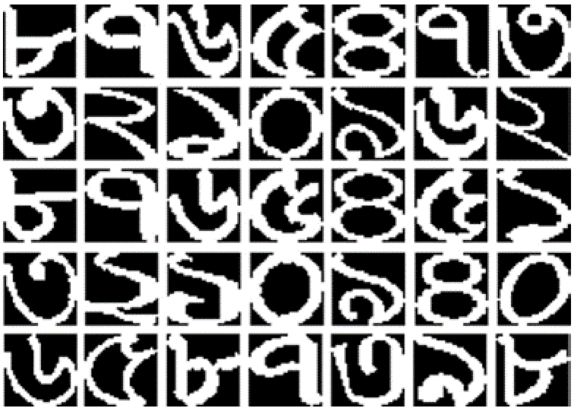

Figure 4.19: Fig. 4.9: Some training samples for the digit classifier neural network.

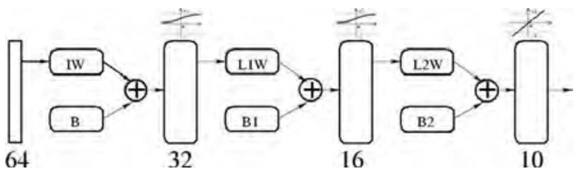

Figure 4.20: Neural network for digit classification.

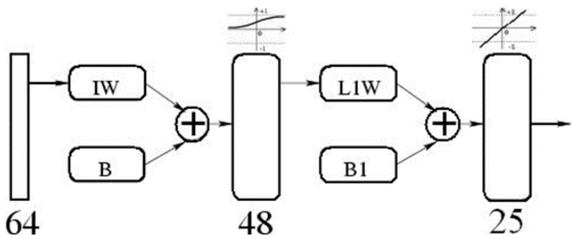

Figure 4.21: Neural network for character classification.

tem. Characters classification neural network is shown in figure 4.10 along with that Bangla characters recognition neural network is shown in figure 4.11 but it has only one hidden layer containing 48 neurons. Furthermore, One Step Secant (OSS) back-propagation algorithm and log-sigmoid function is used as training and transfer function similar to the first neural network. In order to increase the recognition success rate two different neural networks is used to recognize the digits and characters because some Bangla characters have some similarity among them which results in fewer distinguishing features. According to our early discussion Bangladeshi license plates comprised of two rows where first row contains only characters which indicates registration area and type information. Basically, registration area contains multiple characters in comparison to registration type which contains only one character. On the other hand, second row have only six digits which indicates registration number and for this we use digit classifier. But there are some license plates which contains only one row indication both registration number and type where last six segmented symbols are always digits so we use character and digit classifier to recognize these symbols.

4.5 Summary

In this chapter, for Bengali license plates a developed and new ALPR system has been described which provides a robust performance. At first, the position of the vehicle is determined by using the property of symmetry after that in order to locate the license plate region Canny edge detection algorithm along with edges with contours were used which produces rectangular shape similar to license plate. In order to segment the license plate row separation has been performed by using horizontal projection with adaptive threshold and segmentation of digits and the characters is done by using vertical projection with adaptive threshold. Finally, the characters and the digits of the Bangla license plate were recognized by using Artificial Neural Networks.

Chapter 5

Experimental Studies

5.1 Introduction

In this chapter, an ALPR system has been introduced to detect the Bengali license plate using new algorithms for detection, segmentation and recognition stages. We have considered different characteristics and features of Bangla license plates. We have implemented these algorithms on two hundred fifty images in grayscale format. These photos were taken in variable weather and time like bright day light, overcast clouded, dark night time. Using MATLAB 7.2 we implemented these algorithms. These algorithms were also implemented on license plates written in English characters. The implemented set ups and results are presented using MATLAB 7.2 in Table 5.1, 5.2, 5.3, 5.4, 5.5, 5.6 and 5.7

5.2 License Plate Detection

Automobiles and the license plate detection results are presented in table no. 5.1. The average detection rate of our algorithm is 92.8%, using the input images containing variable license plate pattern and abstruse background. The algorithms 3,

Algorithms	Parameters	Values
Proposed Scheme	Symmetry window: Height Symmetry window: Width Inspection Window (IW) Search area (SA)	$(3/4)^{th}$ of input image height $(1/4)^{th}$ of input image width 5×5 16 pixels
SCW [28]	Window: A Window: B Threshold: T Statistical measurement	$X_1 = 3,\ Y_1 = 6$ $X_2 = 6,\ Y_2 = 12$ 0.8 Standard deviation
Duan et al. **4**	**1-** row LP **2-** row LP	$12 \leq \text{Cut} - \text{objects} \leq 20$ $5 \leq \text{Cut} - \text{objects} \leq 10$
Mashuk et al. [32]	-	-

Table 5.1: Experiment set up for license plate detection stage.

4 and 5 attained 73.5%, 85%, and 0% success rate in detecting license plates individually. This clearly ratifies that our algorithm performs way better than the other algorithms in license plate detection. SCW consists of local abrupt change and a threshold that requires trial and error for adjustment. Again, Duan et al rely upon the range of distance. Finally, Mashuk et al is dependent on the location of the license plate.These methods failed to detect license plates owing to specific compulsions, whereas our algorithms can overcome these compulsions to a greater extent.

Method	Situatuin	No. of images	number of Uniform Identification	Uniform Identification(%)	number of identified plate (%)	Accuracy rate in (%)
[t]4*ROID	Bright	290	260	89.7	270	93.1
	Overcast	130	112	86.2	120	92.5
	Nights	80	69	86.2	74	92.5
	Sum	500	442	88.2	464	92.8
SCW [28]	Sum	160	-	-	118	73.75
Duan et al. **4**	160	80	-	-	136	85.00
Mashuk et al. [32]	160	80	-	-	0	0

Table 5.2: Experimental results in license plate detection stage.

Figure 5.1: License plate detection: (a) Original input images, (b) Edge images, and (c) After the application of symmetry detection algorithm and ROID.

5.3 License Plate Segmentation

Outcome of row separation algorithms are illustrated below in figure no. 5.2 Our algorithm obtained accuracy of 98 out of a hundred scales. It can correctly separate the rows of 492 out of the 500 license plates. However, only 4 plates couldn't be segregated because of image noise. SCW and Mashuk et al lack method regarding row separation. However, Duan et al has a row separation method and using this it achieves only 93.75 percent. Our algorithm shows greater results than Duan et al because we use an adaptive threshold. In the presence of noises our algorithm has a better capability in separating rows. Our algorithm has a success rate of 96.0% and 98.8% in character and digit segmentation accordingly. Three other existing Algorithms do not have any kind of capability to segment Bangla characters since Bangla characters have a unique characteristic named Matra. These algorithms were applied for Bangla digit segmentation. These algorithms obtained 97.5 percent, 95 percent, and 97.5 percent accuracy individually in digit segmentation. Our algorithm offers an improved result than the three other algorithms mentioned here since it can resolve the problem derived from image noise by using proper threshold.

Algorithms	Parameters	Values
Proposed Scheme	SMA: Window size (W) $T_n \ T_d$	6 $(1/100)^{th} of\, LParea$ $(1/8)^{th} ofrowheight$
	Window: A	$X_1 = 2,\ Y_1 = 5$
SCW [28]	Window: B Threshold: T	$X_2 = 4,\ Y_2 = 10$ 0.7
	Statistical measurement	Standard deviation
Duan et al. **4**	-	-
Mashuk et al. [32]	-	-

Table 5.3: Experiment set up for license plate segmentation stage.

Algorithm	No. of License Plate	Correct Separated Rows	araccuracy Percentages rate(%)
SAT	250	492	98.4
SCW [28]	160	-	-
Duan et al. **4**	159	75	93.53
Mashuk et al. [32]	160	-	-

Table 5.4: Experimental results in row segmentation stage.

Algorithm	No. of LP	Correctly segmented digits	Success rate (%)	Correctly segmented characters	Success rate(%)
SAT	500	494	98.8	480	96.0
SCW	160	156	97.5	0	0
Duan et al. **4**	170	161	95	0	0
Mashuk et al. [32]	160	156	97.5	0	0

Table 5.5: Experimental results in character and digit segmentation stage.

Figure 5.2: Character segmentation: (a) Original license plate, (b) Manual segmentation, (c) Segmentation with constant threshold **4**, and (d) Segmentation with adaptive threshold (Algorithm SAT).

5.4 License Plate Recognition

Figure 5.4 describes that our digit and character classifiers achieved success rates of 97.5% and 88.7% accordingly in recognizing the characters properly. Successfully achieved recognition rate of the characters are little lower than what the digits classifier obtained due to the complication generated by Matra. Two adjacent characters have less space in between them compared to the space between two adjacent digits.SCW, Duan et al, and Mashuk et al show success rates of 96.7%, 97.5%,

Algorithms	Parameters	Values
	Number of training images	2100
	Performance function	Mean squared error (MSE)
Proposed Scheme	Training function Learning rate	One Step Secant Back-prop. 0.05
	Number of iteration Performance goal	500 10^{-5}
	Number of training images	1000
	Network type	Probabilistic
SCW [28]	Spread constant	0.1
	Number of iteration Performance goal	500 10^{-5}
Duan et al. **4**	Number of training images Network type	1000 Hidden Markov Model
	Training algorithm Tolerance	Viterbi 10^{-4}
	Number of iteration	100
Mashuk et al. [32]	Number of training images Performance function	2100 Mean squared error (MSE)
	Training function	One Step Secant Back-prop.
	Learning rate	0.05
	Number of iteration Performance goal	500 10^{-5}

Table 5.6: Experiment setup for digit and character recognition stage.

Methods	Artificial Neural network	Instances numbers	Right Classified	Success rate(%)
[t]2*Proposed method	Digit classification	650	634	97.5
	Character classification	570	506	88.7
[t]2*Anagnos. et al. [28]	Digit classification	120	116	96.7
	Character classification	120	93	77.5
[t]2*Duan et al. **4**	Digit classification	120	117	97.5
	Character classification	120	102	85
[t]2*Mashuk et al. [32]	Digit classification	120	116	96.7
	Character classification	120	84	70

Table 5.7: Experiment set up for digit and character recognition stage.

and 96.7% individually in Bangla digit recognition derived from license plate image. These algorithms achieved success rates of 77.5%, 85%, and 70% respectively in recognizing Bangla characters. Our neural network shows far better Performance than that of these classifiers in recognizing Bangla characters. SCW used 12×9 sized pixels whereas Mashuk et al. [32] used sizes 16×8 pixels respectively. These methods fail because of having very small pixel size. Duan et al uses 50 × 50 pixels sized character images. As a result it achieves a bit more accuracy that other two. But it still lags behind from our classifier.

5.5 Summary

Comparing all the experimental data with three other existing algorithms, it is clearly proven that the ALPR system we developed offers exquisitely better results in recognizing Bangla license plates.

Chapter 6

Conclusion

6.1 Summary

Recognition and detection of the number of license plate which is written using the language Bangla is done by the use of standard juncture of processing and the set of algorithms used for this is presented in this thesis. In each juncture new approach and algorithms satisfactory for recognizing Bangla license plate has been progressed. Firstly, the image of the vehicle has been converted to a grayscale image using the method COLOR.BGR2GRAY. The image might loose its sharpness of the image, contrast of it, shadow of the image and the structure of the colored image for converting it into a image of grayscale. As such the proposed algorithm in turn performs approximation of the RGB also to reduce and the luminosity and the level of chrominance. Secondly, image has been smoothened by the application of the noise cancellation method. The images are smoothened while preserving its edges using the Bilateral Filter. It also makes sure that no phantom color is produced along the edge and also reduce the phantom color if it appears in the original image. In the third step we have found out the edges of the images using an algorithm called the Canny Edge. We have performed this algorithm on smoothened images as the unwanted edges have already been removed so it is easier to find out the anticipated edges. Fourthly we have found out the contours on the edges of the images using topological analysis of binary images by border following. Using the Python drawContours algorithm the contours on the original images is drawn with graphical color and the algorithm contourArea is used to find out the area of the contours in pixel and this is how the contours is sorted. Lastly for the detection of the license plate the contours that we have found out are used for detecting the perimeter of closed contour,number of contour and the co-ordinates of the contour. For detecting the numbers of on the license plate the image is at first cropped and the again using the COLOR.BGR2GRAY method twice it is converted to grayscale image. Then the image is binarized that is it will now have only two color: black and white. Otsu's binarization method is used for this purpose which selects an optimal threshold by maximizing a criterion for a given image. As a result the characters and digits were extracted and also recognized. Out of 200 images of vehicles of different conditions we have received a success rate of 95% when we tested our algorithms on the images. In comparison to the ALPR system proposed in the literature review our experimental results have outperformed the subsisting formula in the acknowledgement of the Bangla license plate.

6.2 Future work suggestions

The phase of detecting the Bangla license plate of the ALPR system proposed by us is contingent to the discernment of the boundary being rectangular of the license plate. But in many cases the vehicle and the framework of the license plate maybe of the same color as a result it might not have a distinguishable boundary, so our proposed algorithm will not be able to detect the rectangular body which is the license plate number. In compliance to this there are two vowels in Bangla language which overlap each other and often can be seen in the license plate. The algorithm proposed by us is not proficient in differentiating these vowels which overlap each other. In future we aim to improvise our license plate detection and recognition algorithm to resolve complications like these. Furthermore, our proposition can be ameliorated by the introduction of strategies such as color edge detectors and color information might come in use to pace up the efficiency of finding the location the license plate. Also, to reduce the time for execution and to improve the accuracy, algorithm like decision tree will be conducive. Our algorithm can also be implemented in collateral devices for more efficient real time applications.

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Feedback

Md. Ashraful Alam, PhD :

ALPR system developed by us could be more efficient if we introduce more strategies such as use of color edge detector, color information for locating license plates. Moreover, in order to make early decision on recognition stage about registration type and area decision tree can be applied.

Mehnaz Seraj :

Our proposed ALPR system could be more efficient if we had developed a real time Automatic License Plate Recognition system which would have been useful for traffic controllers as well as the law enforcement agencies to capture convicted vehicles.

Rubayat Ahmed Khan :

Our proposed method could be one of the more efficient studies if we could develop more of the character segmentation threshold in a very appropriate course of action.