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For/Dedicated to/To my...

Chapter 1

Introduction

1.1 Definition and Motivation

Number Plate is a rectangular, usually metal plate that bears a sequence of numbers, letters, or both and is issued by a government to identify an officially registered vehicle. It is placed front and back side of any type of vehicles. Number plate detection is a computer vision method where vehicles are identified or recognized using their license plate or number plate. This system involves few processes or steps in the process of identifying the vehicles using their number plate. This thesis targets at the problem of detecting Bangladesh number plates from images. The first thing that will take place will be the sensor or vehicle detector that will be so helpful in activating the digital camera so that it can start taking the image of the vehicle for recognition purposes. After the image of the vehicle has been taken, the first process is finding the number plate region on the image captured. Find the plate region involves looking or detecting the plate region on the image been captured and the method that follows is plate extraction that simply means the plate that have been identified is now been extracted out of the image and from this point we only going to start focusing on the plate image that has been extracted. However, not all Number Plates are veritable i.e. some Number Plates on the vehicles are made up by owners themselves. The fake Number Plates also gives freedom to an increase in vehicles related crimes. Currently, the only method to eradicate this problem is for the police to check vehicles at random and take note of the registration number and call BRTA and look up the number on an offline database[2].So main motivation behind this thesis is make the whole number plate recognition system automated as there have not been any significant work yet to detect the bangali number plates automatically.Besides it will make authorities life easier as they don't have to iterate over a huge database to validate a specific vehicle's licence identification.

1.2 Automatic Bengali License Plate Recognition

Automatic Bengali License Plate Recognition makes bengali number plates detection automate which does not need any human authorization.One important feature of plate detection is the high number of vertical edges in a license plate.Besides there will be many region which actually doses contain plates.So in order to filter out those regions the have split the regions based on contour properties.In that way i have got actual regions which contains the plate.

Before that step removal of noise from images is another vital part of the plate detection.If noises do not get removed it will interrupt to detect the correct region of the plate.Beside segmentation of the plate feature extraction is another important part to recognize the characters.

1.3 Application of ANPR

Automatic Number Plate Recognition has a wide range of applications since the license number is the primary, most widely accepted, human readable, mandatory identifier of motor vehicles.ANPR provides automated access of the content of the number plate for computer systems managing databases and processing information of vehicle movements.

One of the main applications of ANPR is parking automation and parking security: ticketless parking fee management, parking access automation, vehicle location guidance, car theft prevention, "lost ticket" fraud, fraud by changing tickets, simplified, partially or fully automated payment process, among many others.

Border Control is another important application of ANPR.Border Control is an established state-coordinated effort to achieve operational control of the country's state border with the priority mission of supporting the homeland's security againsT terrorism, illegal cross border traffic, smuggling and criminal activities. Efficient border control significantly decreases the rate of violent crime and increases the society's security. Automatic number plate recognition adds significant value by event logging, establishing investigate-able databases of border crossings, alarming on suspecious passings, at many more.

Before that step removal of noise from images is another vital part of the plate detection.If noises do not get removed it will interrupt to detect the correct region of the plate.Beside segmentation of the plate feature extraction is another important part to recognize the characters.

1.4 Challenges

In Number plate detection , we need to deal with a variety of license plates. Each division in Bangladesh has its own license plate pattern and formats of numbers and characters. Moreover, every few years, each division may issue new license plate

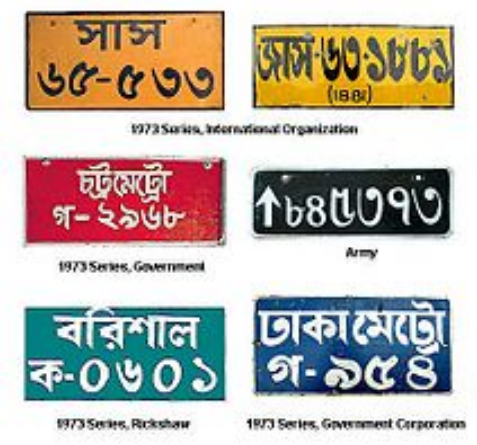

FIGURE 1.1: Different Number Plates

1.5 Scope of the Thesis

- In this thesis our focus is on the number plate detection which is followed by plate recognition.
- We have not considered the rotated images.We have developed the methodology by considering that all images are taken frontally and are not rotated.
- We have prioritised those regions most which have high number of vertical edges. Because these regions have high chances to contain number plates.
- We have used noise removal method the reduce regions that could not have number plates.

1.6 Organization of Thesis

The rest of thesis is organised as follows: in chapter 2 we described the related works that have been done on this topic based on different approaches and methods.In chapter 3 we have described the our approach and methodology briefly which led us to a solution to detect the number plate successfully.In chapter 4 we have discussed the experimental result.

Chapter 2

Literature Review

2.1 Introduction

In previous chapter we have discussed the broadly about ANPR and it usage.In this chapter we am going to discuss related works that have done this field so far.I will discuss related works in two sections.In one section actual number plate detection.In another section we will discuss on Character recognition and separation.

2.2 Number Plate Detection

Ronak P Patel et al[1] used morpologiccal operation to remove pixel having a less than disk radius.Threshold operation was applied to convert gray scal image to binary image.After applying thresholding sobel vertical edge detection was used to find out the regions which have high pixel variance value.Morphological operations aim to remove unrelated objects in the image. Closing and opening are used to extract candidate plate areas from the entire image. Sometimes background areas could get declared as candidate plate. To remove fake plates validation was done using the aspect ratio of the plate.

Hao Chen et al [2] method's is several candidates based on texture information similar plate detection technique using group of lines forming rectangle at the plate boundary. Vertical edge density detector is the next step to find out the actual rigion that contains the plate.Ozbay et al [4] developed smearing algorithm to locate the license plate. Mei Yu et al [5] proposed vertical edge detection followed by size, shape filter for edge area and edge matching technique based on plate model. Farhad Faradji et al [6] first used Sobel edge detection on the image to find vertical edges. Next, vertical projection analysis was

used to locate plate area. False candidates were removed using compact factor, which estimated the densest vertical edge area declaring true license plate. Every character on detected license plates is segmented in character segmentation step. Segmentation techniques based on projection analysis, Hough transform, region growing are proposed in the text.

Sang Kyoon Kim et al [16] suggested a method which was actually based on distributed genetic algorithm to overcome the difficulties dealing with degraded number plates. Clemens Arth et al [17] proposed a r license plate detection and recognition theory where image fragments are collected from real-time video and processed.Humayun Karim Sulehria et al [19] suggested an algorithm that allows the detection of vehicles' number plates using hybrid morphological techniques including hat transformations with morphological gradients and neural networks. Muhammad Tahir et al [20] presented a method for automatic number plate detection and recognition which is based on yellow search algorithm to extract the likelihood ROI in an image especially for yellow licence plate recognition. Ankush Roy et al [21] suggested a method which bypasses difficulty to correctly identify the non-standard number plate characters, by using a pixel based segmentation algorithm of the alphanumeric characters in the license plate. Arulmozhi K et al [22] applied skew correction technique which is applied for accurate character segmentation followed by character recognition Centroid based Hough Transform technique is presented for skew correction of license plate. Amninder Kaur et al [23] suggested pre-processing and number plate localization by using Ostu's methods and feature based localization methods. Roy et al [24] presented a method where image filled with holes is used for licence plate segmentation, removing all the connecting edges and applied a threshold of around 1000 pixels. Shan Du et al [25] presented all the methods which are being used till then and have also listed pros and cons of each method in plate segmentation from images. Gee-Sern Hsu et al [26] proposed a way pf Edge clustering formula for solving plate detection for the first time. It is also a novel application of the maximally stable extreme region (MSER) detector to character segmentation of number plates. Norizam Sulaiman et al [27] suggested a combination of image processing techniques and OCR to obtain the accurate vehicle plate recognition for vehicles based in Malaysia. Bhat et al [28] have also used licence plate segmentation through filling the binary image with holes but this system had limitations on size of vehicles. Sarbjit Kaur et al [29] proposed a way based on bilateral filter during pre-processing for the image and remaining method is same as [24] and [28]. Chi-Hung Chuang et al [30] suggested an approach to overcome the problems like low resolution, long distance image and blurred image with super resolution, by LBP with the concept of fuzzy.. Ayman Rabee et al [31] suggested an algorithm where SVM was applied at last to construct a classifier to categorise the inputs.

2.3 Number Plate Recognition

Norizam Sulaiman et al [12] suggested a combination of image processing techniques and OCR to obtain the accurate vehicle plate recognition for vehicles based in Malaysia.Farhad Faradji et al [5] proposed a way for character segmentation.Every character on detected license plates is segmented in character segmentation step. Segmentation techniques based on projection analysis, Hough transform, region growing are proposed in the text.Xinagjian He et al [6] proposed a way of horizontal and vertical projection analysis for character segmentation. Yuangang Zhang et al [7] proposed a way of character segmentation using Hough Transform. In this, horizontal edges of the plate area were decided initially, using Hough Transform, which helped to segment the characters with the large rotation. Characters were segmented using vertical projection analysis based on the prior knowledge of the plate model. Feng Yang et al [8] proposed region growing algorithm for character segmentation. Shen Zheng Wang et al [9] used connected component analysis for character segmentation.

Chapter 3

Proposed Methodology

3.1 Introduction

We have discussed about different Automatic License Plate Recognition system in previous chapter.Different methods were used in those system considering different constraints.But those systems can not detect bengali number plate as constraints are different.So i have proposed a approach to detect bengali number plate automatically.In this chapter we are going to discuss the approach and algorithm in more detail.

3.2 Image Capturing

Here the digital camera could be used to capture the image. After capturing the image then it is passed to the processes for identification or recognition purposes. Before capturing the image we must have to sure about the position of the vehicle which could be accomplished by placing a sensor or vehicle detector. The sensor or vehicle detector is been used as to detect the vehicle approaching and activate the digital camera as to stand ready or stay ready to capture the image.The most important point is all images should be take frontally.

3.3 Gray Scale Conversion and Noise Reduction

One important feature of plate segmentation is the high number of vertical edges in a number plate and the plate is not rotated and is without perspective distortion. This feature can be exploited during the first segmentation step to eliminate regions that don't have any vertical edges. Before finding vertical edges, we need to convert the color

image to a gray scale image, (because color can't help us in this task). Then next step is remove possible noise generated by the camera or other other noise generating elements. I have applied a Gaussian blur of 5 x 5 to remove noise. if noise-removal method wasn't applied, we could get a lot of vertical edges that produce a failed detection.

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{\lambda\sigma^2}}$$

3.4 Sobel Filtering

The Sobel Edge detector operator is a discrete differentiation operator. It computes an approximation of the gradient of an image intensity function.To find the vertical edges, we used a sobel filter and found the first horizontal derivative.The derivative is a mathematical function that usually finds the vertical edges on an image.

3.5 Thresholding

This the quick way to convert the grayscale image into binary image . The simplest segmentation method .It separates out regions of an image corresponding to objects which we want to analyze. This separation is based on the variation of intensity between the object pixels and the background pixels. To differentiate the pixels we are interested in from the rest (which will eventually be rejected), we perform a comparison of each pixel intensity value with respect to threshold (determined according to the problem to solve).

For thresholding we used otsu's algorithm which required an 8-bit input image.

3.6 Morphological Operations

Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors.

By applying a close morphological operation, we removed blank spaces between each vertical edge line, and connected all regions that could have a high number of edges. After completing this operation we got the possible regions that could contain plates.

3.7 Contouring and Validations

So we have got now many regions that could have plates.We split these regions by using contour properties as most of the region might not contain plates.For each contour detected,we extracted the bounding rectangle of minimal area.We have got the external contours with any hierarchical relationship and any polygonal approximation results. After retrieving the contours we iterated over the each contour to get a rotated rectangle using a built in function.I only considered that a region could be a plate if the aspect ratio is approximately 2.604 (plate width divided by plate height) with an error margin of 40 percent and an area based on a minimum of 15 pixels and maximum of 125 pixels for the height of the plate.We filtered out the regions based on this criteria.

3.8 Crop the Plate

The first step to crop the license plate is to get several seeds near the last rotated rectangle center. Then get the minimum size of plate between the width and height, and use it to generate random seeds near the patch center.Wr want to select the white region and we need several seeds to touch at least one white pixel. Then for each seed, We have used a floodfill implementation to draw a new mask image to store the new closest cropping region. The floodFill function fills a connected component with color into a mask image starting from a seed point, and sets maximal lower and upper brightness/color difference between the pixel to fill and the pixel neighbors or seed pixel. Once we have a crop mask, We have got a minimal area rectangle from the image-mask points and check the valid size again

3.9 Number Plate Recognition

3.9.1 OCR Segmentation

Now, We have got a plate image patch as the input to the segmentation process with an equalized histogram.So then i need to apply a threshold filter and use this threshold image as the input of a contours algorithm to find contour properties.For each detected contour, we can make a size verification and remove all regions where the size is smaller or the aspect is not correct. In this case, the characters have a 45/77 aspect, and we can accept a 35 percent error of aspect for rotated or distorted characters. If an area is higher than 80 percent, we have considered that region to be a black block, and not a character

3.9.2 Feature Extraction

For each segmented character the next step is to extract the features for training and classifying the ANN algorithm.For each character, we have counted the number of pixels in a row or column with a nonzero value. We have normalized it by looking for the maximum value in the data matrix. Wr have applied projected histogram to create the accumulation histogram.Other features use a low-resolution sample image. Instead of using the whole character image, We have created a low-resolution character, for example 5 x 5. We have trained the system with 5 x 5, 10 x 10, 15 x 15, and 20 x 20 characters, and then evaluate which one returns the best result so that we can use it in the system. Once i have all the features, we have created a matrix of M columns by one row where the columns are the feature.

3.9.3 OCR Classification

For classification we have used an Artificial Neural Network machine-learning algorithm. More specifically, a Multi-Layer Perceptron (MLP), which is the most commonly used ANN algorithm. MLP consists of a network of neurons with an input layer, output layer, and one or more hidden layers. Each layer has one or more neurons connected with the previous and next layer. An ANN-trained network has a vector of input with features. It passes the values to the hidden layer and computes the results with the weights and activation function. It passes outputs further downstream until it gets the output layer that has the number of neuron classes.We have only used one hidden layer, then we have defined a matrix of 1 row and 3 columns. The first column position is the number of features, the second column position is the number of hidden neurons in the hidden layer, and the third column position is the number of classes.

Chapter 4

Experimental Result

4.1 Introduction

We have done our segmentation and recognition procedure on various bangla license plates. At first, we collect different images of vehicles frontally. Then using our contouring based algorithms we got our desired license plate images. Then we do some pre-processing and then character segmentation scheme. After character segmentation, by using feature extraction algorithms we collect feature values. Finally we use character recognition algorithms to recognize the characters.

In this chapter, we showed our experimental results and comparisons. algorithms.

4.2 Grayscale Conversion

RGB images need to be converted in grayscale images as color does not help much here.More specifically color information doesn't help us identify important edges or other features.

4.3 Noise Removing

The next step is the removal of possible noises generated by the camera or other ambient noise.I have applied a Gaussian blur of 5 x 5 and remove noise. If we don't apply a noise-removal method, we could get a lot of vertical edges that produce a falied detection.

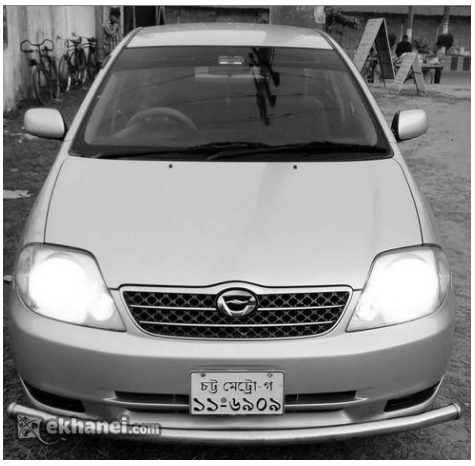

FIGURE 4.1: Grayscale Conversion

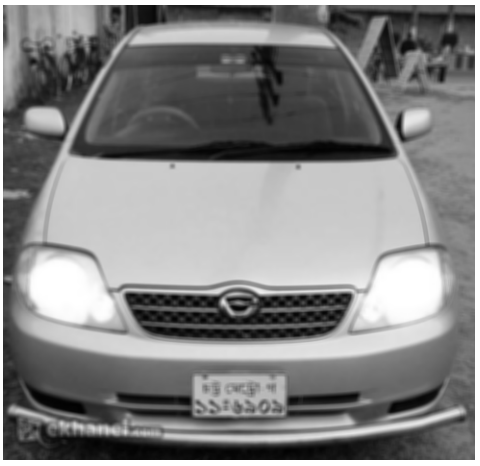

FIGURE 4.2: After Applying Gaussian Blur

4.4 Binarization

In the next step we have used Otsu's method to determine global image threshold. Then using this threshold value binarization is applied on the image. Finally, We have got a binary image of a license plate. The below figure 4.2 shows us the binarization procedure.

4.5 Morphological Operations and Plate separation

By applying a close morphological operation, we removed blank spaces between each vertical edge line, and connected all regions that could have a high number of edges. After completing this operation we got the possible regions that could contain plates.After applying contouring concept and using validation the number plate could be separated.

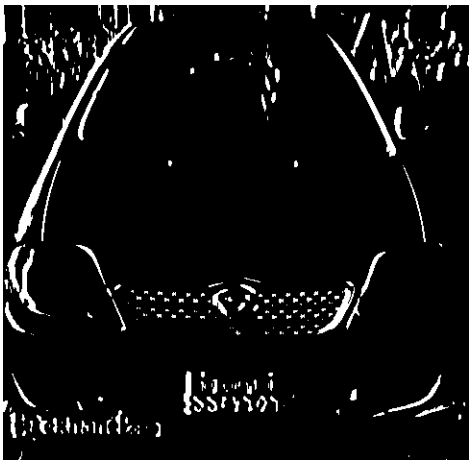

FIGURE 4.3: Thresholding

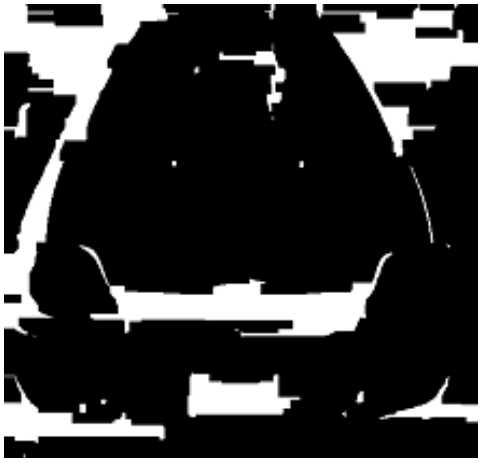

FIGURE 4.4: After Morphological Operation

FIGURE 4.5: Detected Plate

4.6 Experimental Result

We tested our system with several Bangladeshi license plates to measure the accuracy of the system. The system is designed in C++(OpenCV 2.4.8) for recognition of Bangladeshi license plates. The images for the input to the system are colored images with the size of around 600*450. The algorithm was tested using different license plates having various background conditions, light condition and image quality and images were taken under various illumination conditions. The results of the tests are

Units of System	Number of Accuracy	Percentage of Accuracy
Number Plate Detection	32/40	80
Number Plate Extraction	32/40	80

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