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# Abstract

Identification of vehicles is a much needed function for traffic surveillance and control systems. Vehicles can be recognized through license plates which consist of alphabets and numbers. Nowadays, the importance of automatic traffic monitoring has enthralled the attention to the intelligent transport systems. The uniqueness of a combination of characters in license plates can be implemented for providing a vehicle with unique identity which can be beneficent to several fields such as in an arrest of a suspect's vehicle, imposing parking violation fines, entrance authentication and so on. However, it is a labor intensive job to identify all passing or parked vehicles' license plates which can be palliated by Automatic Number Plate Recognition (ANPR) technique. ANPR is systemized to locate and recognize the number plate of a moving vehicle automatically. There are no fixed rules for number plates for Bangladeshi vehicles corresponding to other countries. The recognition procedure of number plates for Bangladeshi vehicles is very tenacious due to the diversity of conditions and patterns. After studying several processes for localizing and recognizing number plates, it is appraised that ANPR is comprised of three basic segments such as number plate localization, extraction and recognition. As the major factor of accuracy or success of recognition of number plates largely depends on the pre-processing steps of captured images of number plates of vehicles, these steps are considered as one of the crucial steps. This proposed report presents the pre-processing steps of captured images of number plates of vehicles. The localization, extraction and recognition processes are still under our discussion and deeper research so that we can efficiently implement these processes for faster and more accurate localization, extraction and recognition of number plates in case of Bangladeshi vehicles as it is undoubtedly challenging as well as a significant task in context of Bangladesh.

## 1.1 Introduction

It is suspected that there are more than half a billion cars on the roads over the universe at present. All of the vehicles have their Vehicle Identification Number (VIN) as their identifier which is primary. Actually, VIN is a license number that enunciates a judicial license to partake in the public traffic policy.

All vehicles world-wide should have its license number written on a license plate - mounted onto its body (at least at the back side) and any vehicle without properly mounted, well-readable and well visible license plate should not run on the streets. Various suspicious activities can occur if there is no legal license plate and with the help of illegal license plate or unregistered license plates, any criminal activity can happen and thus innocent people suffer a lot. So, in order to avoid all of the illegal acts, the process which has become a crying need now-a-days, is nothing but Automatic Number Plate Recognition.

Automatic Number Plate Recognition is a particular form of Optical Character Recognition (OCR). ANPR is a type of technology that enables computer systems to study automatically the registration number (license number) of vehicles from digital pictures. Studying automatically the registration number means transforming the pixels of the digital image into the ASCII text of the number plate.

Considering the ANPR point of view, the quality of image is always a major fact. Special technique is needed in order to avoid blurry portions of images in case of capturing images of fast moving vehicles. It can decrease the accuracy of recognition of license plates drastically. Short shutter time needs to be applied with the combination of high-power illumination in order to ensure the well-balanced image quality. Infrared Radiation (IR) is the best illumination as the retro-reflective plates reflect this type of light perfectly which is not perceptible for the human eye. A constant decent image quality is provided as this combination works really fine during day and night. ANPR cameras are specialized types of CCTV cameras which has software built into it in order to help identifying and capturing license plates on both still and moving vehicles. ANPR technology inclines to be region-specific, owing to the variation of plate from place to place. Basically, it is based on the image processing system.

Automatic Number Plate Recognition System is being implemented all over the universe for surveillance applications. ANPR system can also be implemented in automated enforcement of traffic rules and obligations. Automated enforcement of speed restrictions and associated traffic codes, such as inhibition on specific classes of vehicles (such as those containing explosives or chemicals) implementing particular routes can be applied by ANPR technique. Speed limitation can be mechanistic with the License Plate Recognition (LPR) system obstructing the vehicle at two or more locations and conditioning whether transit among those stoppages and times violated speed limits. An alert to traffic police can be issued automatically by a billing database that a violation is in force. Road security and safety traffic rules are ensured by the LPR technique. It eradicates the redundancy of the time-consuming acts and other violations.

## 1.2 Motivations and Objectives

In the context of Bangladesh, Automatic Number Plate Recognition plays an important role. Bangladesh Police are taking measures to widely generate automated surveillance systems such as ANPR to lessen the hustles or errors and to increase the efficiency. It is also expected to help combat the traffic gridlock in Dhaka. As assumed, Dhaka's two main problems are crime and traffic jam. In this case, ANPR will be efficient.

Although a little progress has been noticed in traffic surveillance in context of Bangladesh, some more advancements and a huge successive progress can be achieved easily by applying ANPR system. Violation of traffic rules being the biggest concern nowadays for Bangladesh, the implementation of ANPR can make the process easier compared to manual traffic surveillance in Bangladesh. If a vehicle runs away after an accident, it can be traced through its number plate. When any vehicle goes through a road within Dhaka city, its number plate will be identified by ANPR technique.

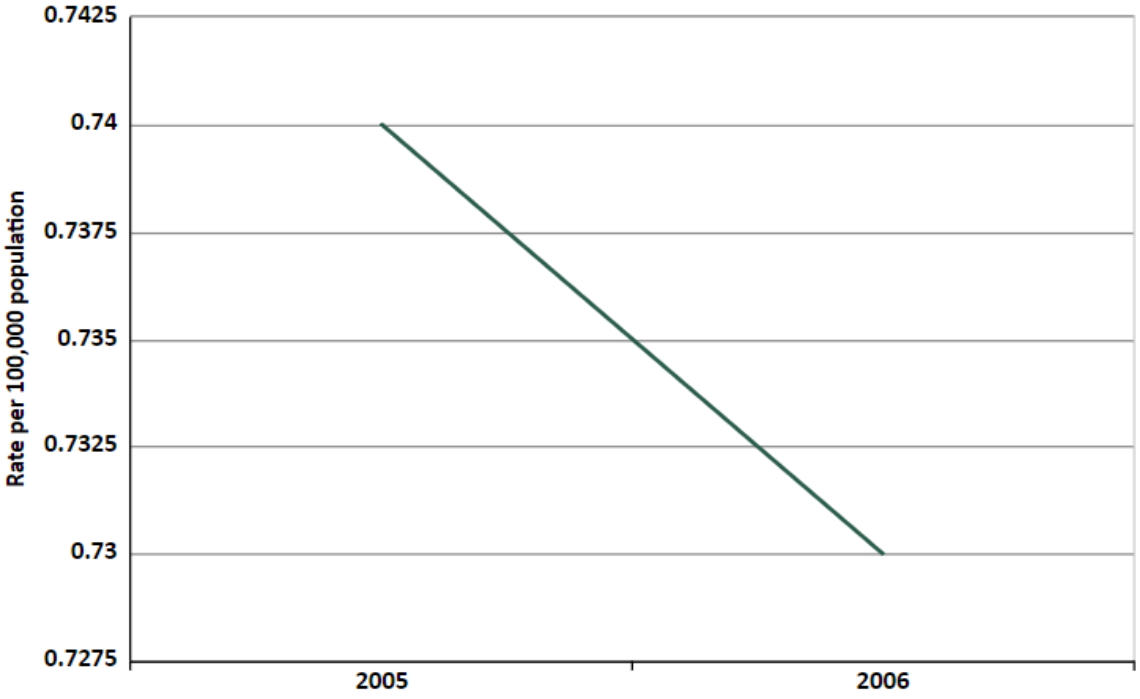


Figure-1: Motor Vehicle Theft Rate in Bangladesh (2005-2006)

Considering the figure stated above, it is noticeable that uncontrolled or illegal implementations of license plates of vehicles are responsible for the high amount of motor vehicle theft in Bangladesh. With a view to eradicating this rate and lessening the aptitude, ANPR technique is much essential.

# 2. Literature Review

Several former research works for recognition of number plate which paved the way to possibilities for the proposed pathway are highly notable.

Considering [1] it is clearly visible that character recognition is performed through various well-known procedures like Fuzzy Logic, Artificial Neural Networks, Support Vector Machine (SVM) based character recognizers. On license plate, stability to noises and modifications of position of characters are allowed using neural network. For image pre-processing, vertical edge density is used to determine candidate for plate region. For gray scale conversion, after the separation of the R, G and B elements from the 24-bit color value of every pixel, the calculation of 8-bit gray value takes place. For density of edge, Sobel Operator is used to calculate gradient image. By the use of Multilayer Perceptron (MLP) Neural Network, the characters which are segmented, are recognized. Failure to the detection of number plate can occur due to the presence of other sign-boards, banners, name-plate of organizations besides the roads and moreover, smashed license plates hamper the recognition process. In a vehicle, existence of so many characters and words may create confusion to the detection process.

Studying [2] it appears that line detection is performed by using Hough Transform which is very sensitive to deformation of a plate boundary needs many memory. Difference of gray value for the boundary detection can show better performance than using line information, though it still has difficulties recognizing a car image which has many similar parts of gray values to a plate region. The HLS method is used for this recognition. Though RGB model is good for color representation on a color monitor, it isn't the best model to represent tint, shade and tone. But HLS model is able to represent all of them. The H.L.S combines Hue, Lightness and Saturation which is the representation of a three dimensional color space. The vertical axis represents the variation of lightness which differs from white to black.

Analyzing [3] it seems that morphological operations are used to detect the high contrast area as effective features to detect license plates. A proper solution to remove the problem of noise and various conditions, License Plate Recovery is used. This method is robust to various types of skewing, scaling and rotations of the extracted plate. First of all, in the character analysis algorithm distance calculation between each pair and finding an index of maximized character with minimum distance is necessary. The total widths and heights of each character close to that cluster is required. Then the averages of widths and heights are counted. For each elements are close to the averages, the character can be said as a correct character. This is presented to solve the total license plate from its fragments and co-ordinates in the directions are denoted. In CA algorithm, the average weight, the average height and the number of correct characters are observed. Then it is verified that if the pixel touches to the top or the bottom of the region. After operating the binary to the new region and labelling, a new set of possible characters is gained from the desired region. Then CA algorithm is applied to obtain the correct character set and new number of characters. After denoting the boundaries, that region is recognized as a license plate with the denoted boundaries.

According to [4], the procedural system architecture is divided into three major portion such as outdoor part, indoor part and communication link. In outdoor part, images are being captured in different intersection and for analyzing images from camera, those captured images are sent to the central control

station which is the indoor part of this system. Then Communication link connects all these cameras to the central control station. The proposed algorithm for this system is based on pattern matching for recognition of license plate characters. In this algorithm, there are fifteen different histograms for each of the letters from A-Z in the 'alphabet' library and fifteen different histograms for each of the digits from 0-9 in the 'number' library. There is flow chart for character recognition that indicates which one of the histograms in the library should be used for the comparison. The histogram extracting from a segment is first normalized before comparing. The process of normalization is done by comparing the width of the segment to the library. After normalization, pattern matching process is being continued. The algorithm only takes characters of which matches are equal or more than 70%.

Considering [5] it is notable that OCR algorithm is applied in this system to manage more deformable images. There are two modules in this license plate recognition system. Firstly, plate detection. Finally, character segmentation and recognition. This propounded system can detect the license plates in different locations to identify the rotation free characters in the plates. Magnitude is used to detect vertical gradients. Morphological analysis and erosion operation are applied to minimize the unwanted noise. In this system, three geometrical features are evaluated area, orientation and density. The main axis and reverse rotation transformation are applied to normalize the character image. In the character segmentation part connected-component based methods are applied and there are two properties -the digits on the license plate are fixed and the characters are in horizontal orientation. Feature extraction must be implemented before character recognition. To implement OCR algorithm there are two features such as extraction of crossing count and in this part it extracted the sub images from the number of hatch and in extraction of peripheral background, area is applied to calculate the character boundary to the image boundary.

Studying [6] it appears that main problems in License Plate Recognition can be solved for small scale facilities such as to understand a sensing system capability for capturing clear image, to understand another sensing system eligible to capture clear image for running vehicles and to develop recognition algorithms efficient for sensor placement adequate for inclined plates. The sensing system method is applied by pairing the image captured with 2 CCDs at a fixed time and under various exposure conditions. A wide dynamic image in range and clear would be gained. The formula of synthesizing algorithm tells that the gray levels at a pixel co-ordinates (x, y) in each image framed by CCD1 is greater than 0 but less than that of CCD2. Again, the gray levels at a pixel co-ordinates (x, y) in each image framed by CCD2 is greater than CCD1 but less than saturation level, which is 255. The equation of dynamic range of the sensing system tells that the signal-to-noise ratio is powered by the inverse of gamma is multiplied by the co-efficient determined by exposure condition. The algorithm to recognize license plate, binarization of the total image is performed. Character region extraction says that the binarized image must be labeled as well as segmented. The total region of hypothesis should align each candidate region has to be proportional to those of real license plate and it is the geometrical property.

Analyzing [7] it seems that for the solution of the low-contrast and dynamic range problems, the histogram equalization is applied. The histogram equalization says that the ratio of i and m is multiplied by 255, where i is the difference between input pixel value and minimum pixel value and m is the difference between maximum pixel value and minimum pixel value. Median filtering can perform to decrease the noise. This filtering says that the corresponding processed result in the x, y axis is equal to the median of the original image in the x-k, y-l axis, where k and l are the members of predefined region which is the covered region by a median filter. The searching range reduction says that the particular

object is kept at the center of an image at the time of making a shot. The particular region is exact at the center 4/9 area. Localization method says that, in the three map retrieving, the saturation, edge and intensity map are applied for character segmentation. The saturation is equal to the difference between 1 and the resultant. For hybrid binarization technique, the average value of license plate is defined by the division of the multiplication of the peaks and its function by the multiplication of image length and image width for removing the dirt from local regions. The threshold is the half of the sum of the average height and width.

According to [8], there are four segments such as image enhancement, vertical edge extraction, background curve and noise reduction, plate search and segmentation. Firstly, the license plate which is rectangular has intense edge and texture information. So, the captured vehicle image is enhanced to clarify the plate area. By using Sobel operator, vertical edge image becomes extracted. The method has proposed a simple algorithm to remove background curves and noise from the edge images. If there is a very long (background curve) or very short (noise edge) actual edge length, then the edge point will be deducted from the edge image. After removing the background curves and noise in the edge image, sliding of a rectangular window is performed to search the plate in the residual image and segment it out from the real vehicle image.

Considering [9] it is notable that Sobel Edge Detection is implemented for detecting edge of a captured image and Otsu method is implemented for detecting intensity of the pixels. Again, Hough transformation is applied for the number plate localization technique. After executing localization and extraction of number plate that portion is sent to a Bangla OCR named Shabdayon which is developed in C++ language to recognize the character of the number plate for next process. In addition, the text output is then stored to a database so that it can check whether it is valid or invalid number plate from server.

Studying [10] it appears that the input image is first segmented by Hue-Lightness-Saturation (HLS) color space from RGB color space. Basically, the HLS model has three-dimensional color space which are Hue, Lightness and Saturation. In graphical formation, the vertical axis represents lightness from white to black. The horizontal line from the center of the double cone represents saturation. Hue is represented with an angle centering on the lightness axis. For doing segmentation of input image, the distributed genetic algorithm is implemented. It can take an image as input and return a label image as output. This method completely follows three main steps such as Evaluation, Selection and Mating. For each step, the system stability is given by the percentage of pixels on the segmented image matching with previous time step for measuring accuracy.

Analyzing [11] it seems that detection and capturing a vehicle image are considered as the first steps. Detection and extraction of number plate are the second steps. Finally, image segmentation technique is implemented to extract vehicles' number plate and Optical Character Recognition (OCR) is used for individual character recognition and using database it can give actual information.

According to [12], Hough transform is implemented to detect lines and in morphological based approach it works with brightness, symmetry, angles and in textures based approach it is usually applied to identify text in images. This system consists of four particles and it works like a photo is taken and then sent to pre-processing step. After that VLP detection receives that image. In this procedure photos are converted to gray color and normalization, histogram equalization are applied. After that Hough

transform algorithm is applied to detect boundary lines. Detecting those images, it sends them to the segmentation unit and after that OCR recognizes the character using HMM model and finally it shows its result in ASCII characters.

Considering [13] it is notable that in the license number identification period, the experimental work of the license plate candidates are conducted. The identification period comprises of two principal tasks – separation of character which is dealt with a hybrid of blob coloring techniques followed by connected components and recognition of character with iterative pathways. While seeking for license plate in an input image, the quad colors (black, white, red and green) should be focused. Extra data for discriminating genres of license plates can be provided by the compositional semantics of license numbers. In the license plate locating module, an input RGB image is intersected into two categories as color edge detection and color model transform. The color edge detector rejects irrelevant edges by sensing only three types of edges as red-white, green-white and black-white and discarding additional edges in an image. Transformation of the RGB (Red, Green, Blue) space into the HSI (Hue, Saturation, Intensity) space is performed for the fuzzification of edge, hue, saturation and intensity of the image. A fuzzy map is integrated by a two-stage fuzzy aggregator. On the basis of the aggregated fuzzy map, the large interesting domains are destined to be license plate candidates. In the license number identification module, input license plate candidates are preprocessed conducting binarization, labelling of connected component and noise dismissal. Binarization takes place in order to highlight characters and subdue background. A connected component algorithm banishes unwanted image domains. Categorization of character, Topological Sorting, Template Test, Self-organizing (SO) recognition take place to recognize characters.

Studying [14] it appears that for wavelet transform, Haar scaling function is implemented. Every gray-level image bands' pixel value is binarized by a threshold which is predefined. The four sub-images LL, LH, HL and HH determine the original lowpass-filtered image, horizontal directional characteristics, vertical directional characteristics and cater-corner characteristics respectively. After completing wavelet transform, license plate is located roughly. In LH sub-image, the region along with high horizontal difference as well as a reference line with maximum horizontal difference is observed. Considering the reference line, the area of searching of license plate can be diminished. As the size of license plate may vary depending on the distance between car and camera, the size of the searching mask must be decided before tracing the region which is candidate. The horizontal projection curve is examined cautiously to obtain the peaks. Various maximal sets of all peaks define the probabilistic width of the license plate. The possible license plate region will be the analogous mask with maxima value. After extracting all license plate regions and ascertaining the features of candidate regions according to the geometrical properties, a column search is carried out. Calculation of the value of total pixels are conducted in the checking unit. The column for which the value gets smaller than the threshold, is refused from being a part of license plate region. The left and right limit of license plate can be traced by implementing the column search method. The row search method can trace the top and bottom limit.

Analyzing [15] it seems that obtaining an image, the Pre-processing part performs the adjustment of the input image and after that Harris Corner algorithm is implemented for the extraction of the feature or all the corner points from the image. The Sliding Window (SW) method takes part with a view to tracing the most probable license plate region. In order to adjust the majority of images, Soft Thresholding (ST) is implemented as a portion of Sliding Window (SW). Aspect ratio (AR) boundary is established to

eliminate multiple possible candidate region of license plate. In the segmentation part, Super Resolution method is applied to maximize the license plate which paves the way to implement the Adaptive Thresholding method skillfully. Then morphological function is applied to eradicate the redundancy of license plate region. Later, CCA is implemented to trace the connected component from the license plate. In order to neglect false-detected non-character region, AR, PC and Height are consolidated as the soft threshold.

According to [16], the system is divided into four section and those are vertical edge detection, edge statistical analysis, hierarchical-based method and morphology-based license plate extraction method. Kirsh, Rober, Susan operators are notable ways for edge detection. Linear filter is applied to smooth the image before vertical edge detection. The process of fixing the regions are divided into three such as attaching the lines, attaching the line to rectangles and detecting the rectangles .Fake license plates are also detected in hierarchical based method part. Edge statistics method faces a little dilemma to detect the license plate and then hierarchical based method is applied. In this method forth scale layer is used to recognize an image clearly. Component analysis, feature extraction, abbreviation of candidate regions are applied in morphology based license plate extraction methods.

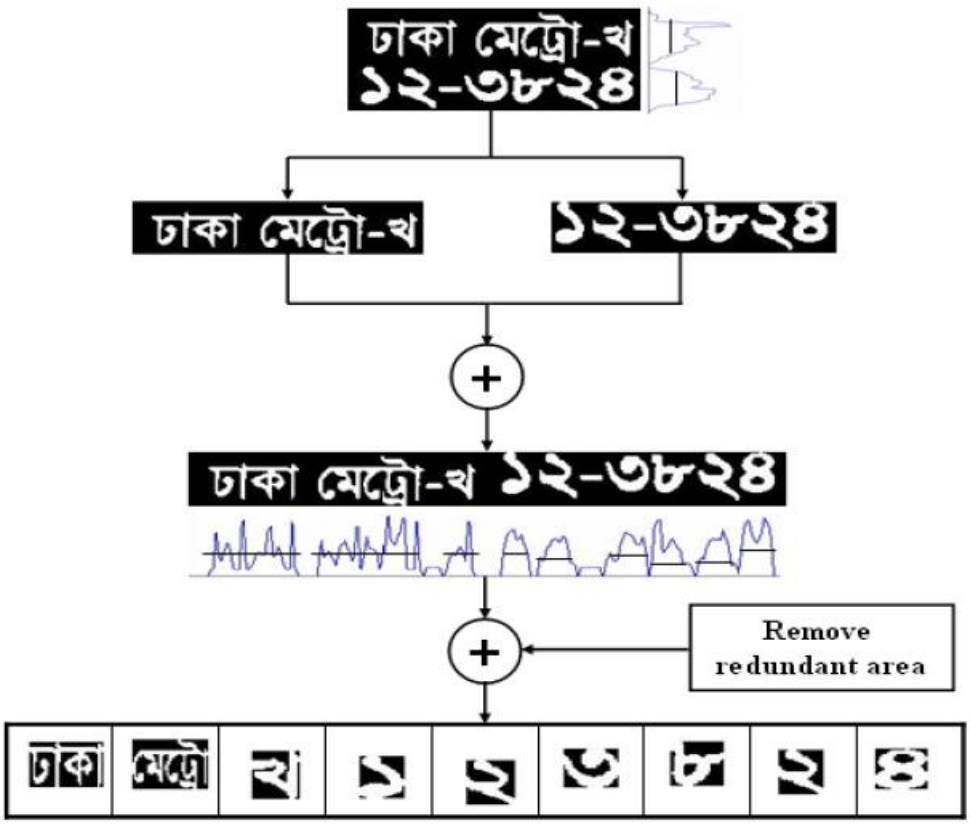


Figure-2: Bangla Character Segmentation System (adopted from [1])


(a) (b) (c) (d)

Figure-3: Examples of successful number plate detection and recognition (a) Gray scale image, (b) after enhancement plate region detected, (c) successful number plate extraction and (d) successful character recognition (adopted from [1])

The literatures are summarized and reviewed in a table including its methods, datasets and accuracy like below:

| Papers | Datasets | Methods | Accuracy |
|---|---|---|---|
| [1] | Used their own dataset | Edge Analysis Method combined with mathematical morphology, Vector Quantization (VQ), Diverse Neural Network Architectures like Pulse Coupled Neural Networks (PCNNs), Time Delay Neural Networks (TDNNs). | 92.1% in Number Plate Detection and Extraction, 97.53% in Segmentation, 84.16% in Number Plate Character Recognition. |
| [2] | Used their own dataset | Hough Transformation, HLS (Hue, Lightness and Saturation). | 81.25% in recognition using Edge Detection. 85% using Gray Value, 91.25% using HLS Color Model. |
| [3] | Used their own dataset | CA (Character Analysis) algorithm. | The average accuracy of the license plate detection is 98%. |
| [4] | Used their own dataset | Pattern Matching procedure, Histogram Extraction, Normalization process. | The average accuracy rate is equal or more than 70%. |
| [5] | Used their own dataset | Morphological Analysis, Erosion Operation, Reverse Rotation Transformation, Connected Component based methods. | 98.6% accuracy rate in case of the rotation free character recognition. |
| [6] | Used their own dataset | Binarization, Synthesizing Algorithm, Sensing System Capability, CCD (Charge Coupled Device) Comparison. | 99.3% of accuracy in case of extracting images of original licenses and the plate is successfully recognized. |
| [7] | Used their own dataset | Histogram Equalization, Median Filtering, Binarization. | The total rates of location and segmentation are 97.1% and 96.4% respectively. |
| [8] | Used their own dataset | Vertical Edge Extraction using Sobel Operator, Sliding Procedure. | Location rate 91.3% using Line Sensitive Filters, 99.7% using the proposed method. |
| [9] | Used their own dataset | Sobel Edge Detection Method, Otsu Method, Hough Transformation. | The accuracy rate of the localization of plate region is 88%, the extraction of the plate is 77% and the recognition unit is 62% . |

| | | | |
|---|---|---|---|
| [10] | Used their own dataset | Hue-Lightness-Saturation (HLS), Distributed Genetic Algorithm. | The accuracy of extraction rate is 92.8%. |
| [11] | Used their own dataset | Image Segmentation Technique, Optical Character Recognition (OCR). | Failure to the accuracy rate can occur and the average accuracy rate of license plate recognition is quite decent. |
| [12] | Used their own dataset | Hough Transformation (HT) Method, Normalization, Histogram Equalization, Optical Character Recognition (OCR), HMM (Hidden Markov Model). | 97.61% is the accuracy rate in case of character segmentation module. 97.52% is the accuracy rate in case of OCR module. In case of the whole system the rate is 92.85%. |
| [13] | Used their own dataset | Blob Coloring Technique with Connected Components, Color Edge Detection, Fuzzification, Binarization, Topological Sorting, Self-Organizing (SO) Recognition. | The overall accuracy rate with first group of images is 98.8% and with second group of images is 96.7%. |
| [14] | Used their own dataset | Haar Scaling Function, Binarization, Horizontal Projection, Column Search Method, Row Search Method. | The Overall accuracy rate is 92.4%. |
| [15] | Used their own dataset | Harris Corner Algorithm, Sliding Window (SW), Soft Thresholding (ST), Super Resolution Method, Adaptive Thresholding, Connected Component Analysis (CCA). | The accuracy rate of this proposed method is 93.84%. |
| [16] | Used their own dataset | Vertical Edge Detection, Hierarchical-based Method, Morphology-based Method, Edge Statistics Method. | Overall 99.6% accuracy rate in detection of license plates. |

# 3. Methodology

Basically, ANPR system works in a successive way such as at first an image is captured and then it begins the image processing steps. One of the crucial steps is pre-processing the captured image as the captured image has a high possibility of being blurry, color-inaccurate and unprepared for the recognition phase. In recognition phase, OCR is generally implemented to recognize characters.

This proposed report presents the pre-processing steps of captured images to improve the light conditions and to fix the noise for better understanding of characters of number plates. The generalized methodology of ANPR system seems like the following figure:

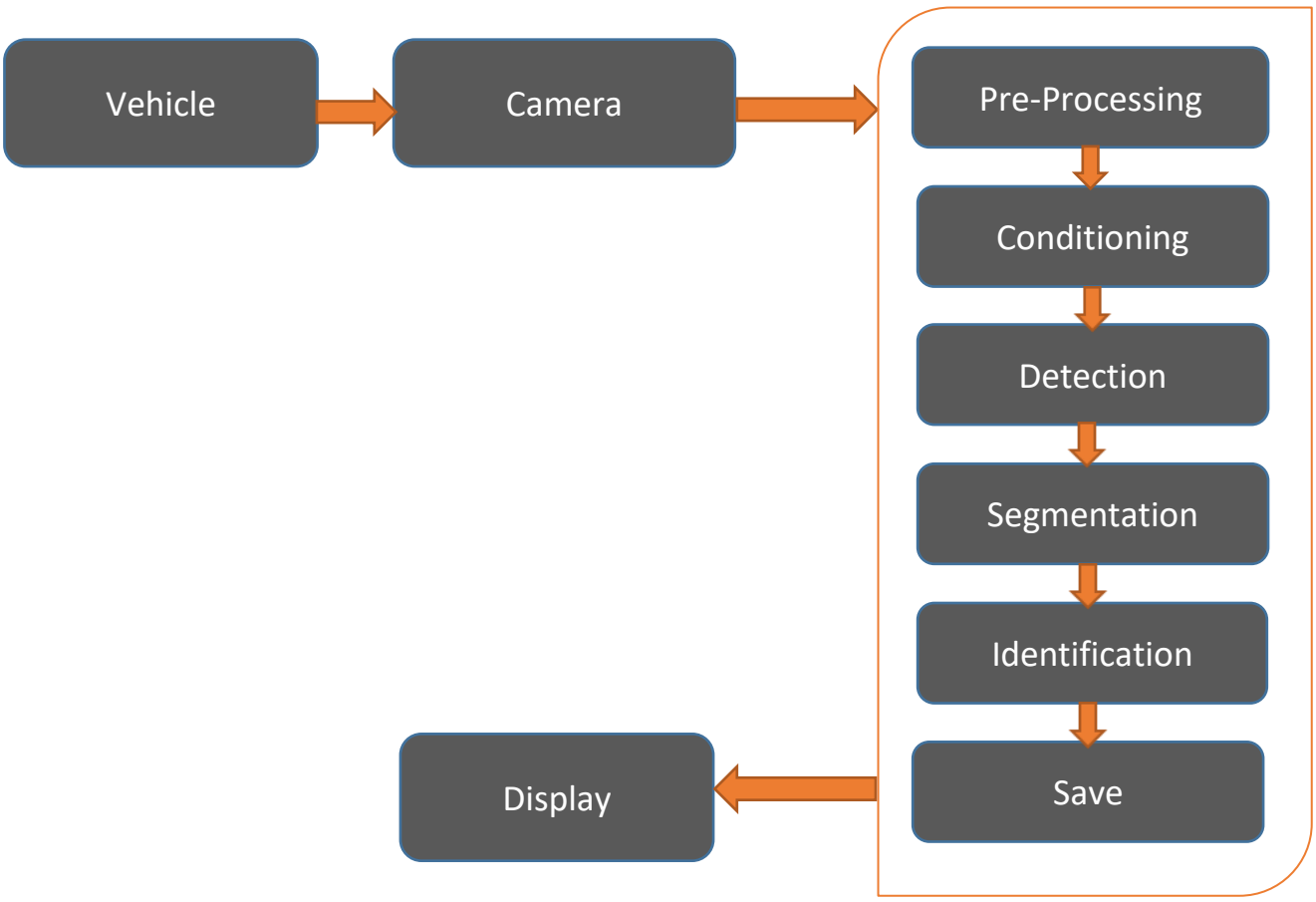


Figure-4: Flow Diagram of Automatic Number Plate Recognition System

At first, an image is captured from vehicles using cameras. Then it becomes quite necessary to process the captured image. It passes through a sequential procedure. Condition is so much essential as it determines the present condition of an image. After finishing conditioning process, it moves to the detection process. In this process, detection of license plates are placed to locate the exact position of license plates. After detection, the license plate needs to be segmented according to the rule of BRTA in case of Bangladeshi License Plate. Identification can be performed using OCR generally. After identifying the license plate, it is saved and displayed.

There are steps like detection, extraction and recognition which are essential for final output of this ANPR system are still under our discussion and deeper research so that we can efficiently implement these processes for faster and more accurate detection, extraction and recognition of number plates in case of Bangladeshi vehicles. So, we will select the appropriate method for us to detect, extract and recognize the license plate automatically as well as we will design our work flow for this recognition system as soon as possible. Again, we have studied that they have used their own datasets. So, we might use our own datasets for this recognition system of the license plate automatically.

# 4. Conclusion

After all, we can ensure that Automatic License Plate Recognition will help to control the traffic in our country. This type of technology will be very much helpful for the crime detection and some other violence eradication in our country. So, we will select the proper technique to activate this system in order to assist the traffic surveillances as soon as possible for the betterment of our beloved country.

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