Video Sensor-Based Automatic License Plate Recognition of Static and Moving Vehicles

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Abstract - **In Bangladesh, present transportation system needs suitable control schemes to ensure safety and mobility to the road users. License Plate Recognition (LPR) is one of the control schemes which can be used to ensure road safety using video sensors. Moreover, from installation point of view, it is cheaper than Radiofrequency Identification (RFID) system. Automated LPR is adopted to reduce human involvement which causes loss in accuracy and reliability in reading license plate. The extracted information from LPR can be used in various schemes, such as electronic payment system, traffic surveillance and extracting vehicle trajectory. In this paper, we are presenting an offline dynamic LPR system, which uses geometric properties of Bengali alphabets stored in alphabet template database to recognize license plates from video. The system comprises of three main components: 1) License Plate Locating (LPL), 2) Character Segmentation (CS), and 3) Geometric Character Recognition (GCR). In this regard, the image is converted into a binary image considering morphological operations and color modification. A new ratio-based detection algorithm has been proposed for the segmentation of license plate. Finally, the alphabet template database and the character extracted from detected license plate are correlated to recognize alphanumeric character which deduces the plate number. Thus, the plate number can be utilized for further action.**

Keywords: Automated license plate recognition, Bengali alphabet, ratio-based detection, character recognition.

I. INTRODUCTION

In recent years, with the growing number of road accident due to reckless driving and terrorist activities, security and safety have become prime concern. The need for security related services is increasing and the demand of finding new attempt to save ourselves by using technology. One of them is automated traffic surveillance systems which can work independently with minimal human involvement. An automated system that can identify suspected vehicles and alerts the corresponding authorities immediately when any incident occurs. This will decrease the response time of the authorities which can protect lives. Traditionally, to identify a vehicle automatically, electronic surveillance systems have relied on installed devices. The device is pre-installed and will transmit a special identification code upon request. Afterwards, the code is used for identification of the vehicle, granting access if authorized. For an area of high traffic volume, this approach will present considerable work to find any vehicle. With the increasing number of vehicles, increase in accidents and parking demand have become serious issue today. Most of parked vehicles are monitored manually by security guards who cannot keep a track. In Bangladesh, the problem is getting acute day by day as people are getting interested on private cars more than before for a comfortable trip. An efficient ALPR (Automatic License plate Recognition) is badly needed to cope up with the problems related to growing number of vehicles.

Over the last few years, ALPR has become popular for vehicle surveillance. Several researches have been carried out to identify the number plate of vehicle such as a car, bus, truck, scooter, or motorcycle. In 2013, an ALPR system consists of three main stages: 1) Number Plate Localization (NPL), 2) Character Segmentation (CS), and 3) Optical Character Recognition (OCR) were recognized [17]. The NPL stage is where the Number Plate is being detected. The Character Segmentation stage is an important pre-processing step before applying OCR, where each character from the detected Number Plate is segmented before recognition. In the last stage, characters are segmented from the Number Plate so that only useful information is retained for recognition where the image Artificial Neural Network (ANN) system is used [7],[13] which required large number of samples and neurons to achieve good performance. Probabilistic neural network (PNN) is applied incorporating Bottom-Hat filtering, Otsu's thresholding, opening, labeling, closing, correction of the skew, and extraction of the rectangular regions is done which can possibly contain the plate [9]. Moreover, two major components were considered [16]. Firstly, a new binary

method, i.e., the shadow removal method, which is based on the improved Bernsen algorithm combined with the Gaussian filter. Secondly, a character recognition algorithm known as support vector machine (SVM) integration. In SVM integration, character features are extracted from the elastic mesh, and the entire address character string is taken as the object of study. In Sobel filter was used to find the edges of the vehicle license plate [15]. Support Vector Machine (SVM) and Contour let Transform were used in to find out the model of the vehicle [12]. They showed numerical results on specific data set of about 70 pictures which cannot be applied to realtime video stream. Some researchers also used monocular images are used for vehicle recognition [14]. They used canny edge detection to detect the presence of vehicle and SVM to recognize the vehicle plate. Maximum Average Correlation Height (MACH) filter and Log r-theta Mapping techniques were applied to recognize the type of vehicle irrespective of scale and rotation variation of vehicles [11]. The MACH filter was used for detection of targets in cluttered environment. Optical Character Recognition (OCR) technique was used, which is a widely used technology that translates scanned images of printed text into machine encoded text [18]. Here, an OCR algorithm based on feed-forward neural network is being proposed where two non-overlapping real character image data sets are used for training and testing the proposed neural network. The two non-overlapping image data sets were used to emulate real-world scenarios.

Artificial Neural Network (ANN) is widely used intelligent computing structure for pattern recognition. The most common used ANN is the multilayer feed-forward neural network which has a simple internal structure that can classify inputs into a set of target categories. Binary pixels value and features extraction process was also used to organize the inputs of neural network in [1] and [8] respectively whereas, the later one is the most common used method for neural network, which can achieve good performance even under difficult environment. However, the feature extraction normally needs complex computation or multiple stages to extract features. Similar methods are present which use extra procedures during the training stage or after obtaining the results of neural network to handle difficult characters that belong to the sets of ambiguous characters. Additional training is used for the difficult characters (e.g., I/1, B/8, and O/D) and comparison of distinguishing parts of ambiguous characters is performed [4].

The statistical classifiers can be divided into two sub-classes: single stage classifier and multistage classifier. Character features are extracted from the elastic mesh, and the entire address character string is taken as the object of study [16]. A two-stage hybrid OCR system is presented to improve the recognition rate [10]. It firstly uses four statistical sub

classifiers to independently recognize the input character and then the results are combined using the Bayes' method. Secondly, if the recognized character from the first stage belong to the sets of ambiguous characters (e.g., I/1, B/8, and O/D), a structural stage is used for a further decision. The large contrast between the characters and the background is exploited to detect license plates with black characters over white backgrounds [5]. While some other algorithms assumed that the density of edges in the license plate region is larger than other regions if the contrast of the character and the license plate is sufficiently large. For example, some research works scanned the vehicle images with N-row distance to count the existent edges [2-3]. Regions with high edge density will likely have the license plate inside. Gabor filters were applied to detect license plate and tested the algorithm with images acquired in a fixed angle and achieved a very good performance [6]. Vector quantization (VQ) has also been used as a feature to encode images for license plate detection [19]. In this method, vehicle images are divided into rectangular blocks and compared with a difference ratio with a specified tolerance to extract the expected block. By passing the image through a few morphological operations and thresholding, the license plate region can be easily located. Common pattern matching technique is a simple technique for the recognition of single font and fixed size character, which is a suitable approach for ANPR systems. Incorrectly segmented characters from the character segmentation stage, where characters are not in the expected position or few of them are missed, may affect the OCR recognition. The neural networks and statistical classifiers, which give better outcome compared to common pattern matching technique, can overcome this problem because of their strong memory and self-adapting ability. However, to achieve good performance, large number of samples and neurons are needed to obtain the neural networks. Each system proposed for vehicle identification and number plate recognition in the literature survey has its own pros and cons.

In this paper, a system has been developed to recognize vehicle number plate of static & moving vehicle through video analysis for Bangladesh. The DNPR (Dynamic number plate recognition) system comprises of three main stages: 1) Number Plate Locating (NPL), 2) Character Segmentation (CS), and 3) Geometric Character Recognition (GCR). In the irst stage, number plate is detected from video. It uses plate extraction based on spatial differentiation. The Character Segmentation stage is an important pre-processing step before applying GCR, where each character is segmented before recognition. In the last stage, the segmented character is matched with predefined character to get alphanumeric character. Character matching algorithm for license plate recognition plays an important role in video analysis of the number plate image.

II. METHODOLOGY

The license plate recognition process can be divided into three steps as shown in figure 1: (1) Locating Plate Region (2) Character Segmentation and (3) Character Recognition. Each step is carried out by an independent module as shown below:
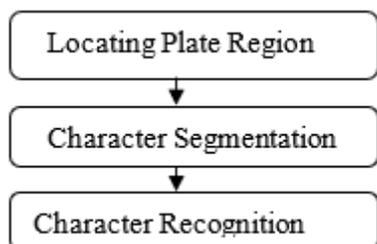

Figure 1: Flow Diagram of License plate recognition process

An input video conveyed a frame to the system is first examined by comparing dimension ratio (DR) with an initially given value which is derived from original plate's length to height ratio and processed using derivative of the image and a few morphological operations to obtain the vehicle license plate region. Then the plate region is segmented to each individual digit and character, finally Character Recognition is done by template matching.

Two user defined functions: (1) Plate Extractor and (2) Plate reader are applied here. Plate extractor works for locating plate region (LPR) and extracts the region of interest (ROI) from the image whereas plate reader controls the whole process of segmentation and recognition of characters. Figure 2 represents the framework of the algorithm for the process.
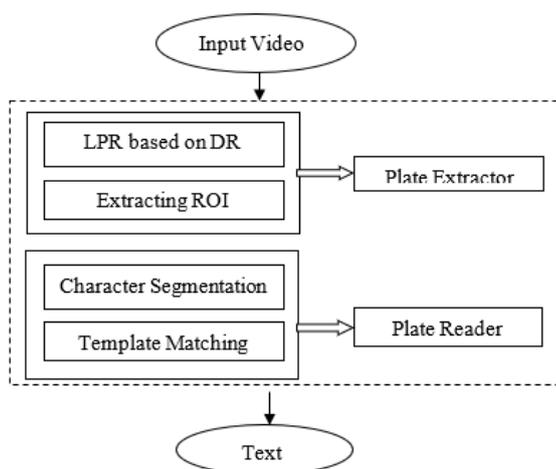

Figure 2: Framework of the algorithm of plate extraction and recognition process

2.1 Locating License Plate and Extraction

For locating the plate area first the image is converted to gray scale which limits the color variation to monochromatic

and adjusts illumination. Then spatial differentiation is done for filtering the image. In image processing filters are mainly used to overpower either the high frequencies (sharp edges) in the image or the low frequencies (smoothing variation) in the image. As an image is a function of two (or more) variables it is necessary to define the direction of differentiation. For the two-dimensional frame, we have horizontal, vertical, and skewed direction which can be considered as a combination of the two. Here we have used the axes of the frames as the directions for differentiation. Spatial differentiation works as an edge extraction tool and issues a logical image with highlighted edges. It highlights the edges of the objects in the image, as edge is a place where rapid change in the image intensity function occurs. This image is passed through morphological operations to reduce noise and make the plate area extracted. Two basic operations in mathematical morphology are erosion and dilation. Usually, Dilation and erosion are used in combination to improve image processing operations. Both operators take two input data: one is an image and the other a structuring element. For a binary image, white pixels normally represent foreground regions, while black pixels denote background.

Then the set of coordinates corresponding to that image simply becomes the set of two dimensional coordinates of all the foreground pixels in the image, with an origin normally taken in one of the corners so that all coordinates have positive elements. Erosion and dilation are done using disk shaped structural element as it matches the most with our region of interest to make the plate region a white rectangular box. The geometric information of the white regions is obtained using blob analysis. Using the geometric information and ratio-based segmentation the actual license plate is detected. Ratio based segmentation considers the geometric aspect ratio of the license plate and compares the ratio with all the detected objects. The matched one with the user defined geometric aspect ratio within a certain tolerance limit is the actual license plate. This process is displayed in a flow chart in figure 3. In figure 4 the changes in the image with the progress of the process is shown.
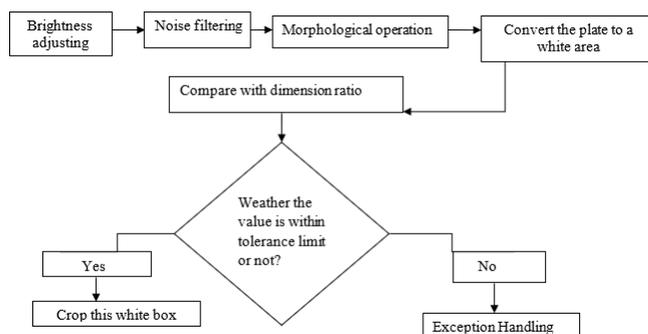

Figure 3: Number Plate Locating

(a)

(b)

(c)

(d)

Figure 4: Images of different stages of Locating and Extracting Plate Area (a) After spatial differentiation; (b) After morphological operation locating white box region; (c) Initial image; and (d) Extracted image

2.2 Plate Recognition

The extracted section of the input frame image, where the plate is expected to remain, is directed to plate reader for processing and recognition of the numbers. The recognition process composed of three main components: (1) Preprocessing (2) Character segmentation and (3) Character recognition as shown in figure 5.
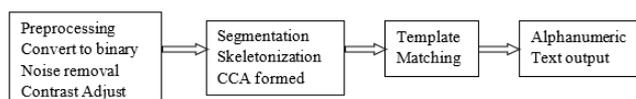

Figure 5: Major Components of Character Recognition

2.2.1 Pre-processing for Character Segmentation

Preprocessing is the first step of character segmentation which includes several morphological operations and gives an

output image with lower noise for segmentation. Under this process first the image is resized to protect it from alteration, as alteration can cause loss of important information. Resizing image also reduce bandwidth required for storage and helps faster analysis. Then the image is converted to gray scale to reduce color variation. Median filtering is performed on the image for thresholding and image equalization. The median filter goes through each pixel in the image and considering its neighbors decides whether it is representative of its surroundings or not.

It replaces the pixel value with the median value which is calculated by sorting all the pixel values from neighborhood into numerical order. After filtering erosion and dilation are performed, the image is adjusted to increase the contrast. Most often to separate out the foreground text from the background simply thresholding is done based on intensity. However, simple thresholding fails due to variation in illumination of background. So, background subtraction is done so that straightforward thresholding can achieve better results on the image. Skeletonization is done for reducing foreground regions in a binary image to a skeleton that only keeps the connected components discarding other foreground pixels. Thinning produces a sort of skeleton by reducing all object to lines, without changing the structure of the image. It successively erodes away pixels from the boundary while preserving the end points of line segments at which point only approximate skeleton is left. 2D convolution on the skeleton of the image fills the blank spaces. Convolution is used to modify spatial frequencies of images so that all the pixels can be treated.

For pixels, where there are no surrounding pixels, dependent analysis gives a different result than expected as ignoring them smaller image can be found. In convolution only 3x3 matrices are considered setting all border values of a kernel to zero. The filter studies successively every pixel. For each pixel, the pixel value is multiplied by 8 surrounding kernel values. Adding all these values the final pixel is set. All these pixels are scanned by connected components analysis which groups its pixels into components based on pixel connectivity. That means all pixels in a connected component share similar pixel values.

After completing the scan, a specific morphological operation to the binary image is applied. It removes pixels to shrink objects without holes to a minimally connected stroke and with holes to a ring. The default connectivity is 8 for two dimensions. Connected component are created out of the filtered image and boxes are used to fit the components. The steps of preprocessing are shown in figure 6.

(a)

(b)

(c)

Figure 6: Processing for character segmentation (a) Initial image; (b) After morphological operation; and (c) Binary image for segmentation

2.2.2 Character Segmentation

In character segmentation the property of the binary image is measured using bounding box which returns the smallest rectangle containing the region. This matrix will be submitted to the final stage of recognition by Geometric Character Recognition.

2.2.3 Template Matching

The final stage of DLPR (Dynamic License Plate Recognition) is template matching. It is one of the most used Character Recognition techniques. It is the process of finding the location of a sub-image, inside an image which is called a template. Template matching involves determining similarities between a given template and windows of the same size in an image and identifying the window that produces the highest similarity measure. It works by pixel-by-pixel comparison of the image and the template for each possible displacement of the template. This process involves the use of a database of characters or templates. There exists a template for all possible input characters. Templates are created for each of the alphanumeric characters that are used in Bengali number plates using 'Regular' font style. For recognition, the input character is compared to each template to find either an exact match, or the template with the closest representation of the input character. And the highest matched template is given as output.

III. DATA COLLECTION AND RESULTS

For our experiment we collected data using a 13 mega pixel digital camera at daytime with a downward angle of inclination of 30 degree and the relative speed between the camera and the vehicle was 9 kmph. A sample size of 100 frames was used for analysis. From 100 frames 70 were located properly, 68 were recognized by the process and 5 frames gave the exact results. A portion of results found for different frames is presented in table 1.

Table 1: Results showing different matching percentage groups

Percentage Groups	No. of Frames	Total Characters	Matched Characters	Matching Percentage
(90-100) %	5	9	9	100 %
(70-90) %	17	9	8	89 %
(50-70) %	22	9	6	66 %
<50%	24	9	4	44 %

IV. CONCLUSION

In this paper, we developed an automatic license plate recognition system customized for real-time Bangladeshi vehicles license plate. According to our experiments, our proposed extraction process works well for images captured from specified height and angle. However, it fails in the scene containing extremely uneven illumination distribution. So, there is room for improvement in this algorithm since it does not work effectively in situations under dark lights and errors from different shapes of the characters we extract. Artificial Neural Network (ANN) can be used for pattern recognition. But overall, this will be the direction of further research.

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