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Analysis of Feature Extraction Techniques for Vehicle Number Plate Detection

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***Abstract*—Vehicle identification plays important role in Intelligent Transportation System. Vehicle is identified uniquely by its number plate. It is used for applications like identification of authorized vehicles, providing controlled access to restricted areas, and law enforcement. In the proposed system the license number of the car is checked against the database of authorized users and only authorized vehicles will be allowed to enter the restricted area. Feature extraction is the important step in pattern recognition. The performance of the system depends upon feature extraction technique. It is necessary to select and extract relevant features for improving the performance of the whole system. The proposed system will use feature extraction technique using Histogram of Oriented Gradient. The result of vehicle identification depends on number plate detection. This paper focuses on number plate detection using different algorithms.**

***Keywords* — Feature Extraction, Histogram of oriented Gradients, Image Processing, Number Plate Detection, Pattern Recognition, Vehicle Identification.**

I. INTRODUCTION

Vehicle identification plays important role in intelligent transportation system (ITS) [1]. A vehicle number plate is attached to vehicles for official identification purposes. The identifier can be used for uniquely identifying a vehicle. There are numerous reasons why it is necessary for individuals or organizations to identify a vehicle and thus its owner. Examples are law/police enforcement, traffic control, and access to restricted areas, electronic toll collection or checking parking permissions purposes [2]. In some of the applications like traffic law enforcement, road monitoring and expressway toll system, where number plate recognition is used, it is necessary to process a large number of vehicles in a short time. In daily life there is huge traffic on roads, in this scenario application has to do very fast processing. Otherwise, violators and criminals can escape.

The detection of a single number plate and the recognition of its characters in a reliable way is an expensive task, since it relies on special license plate recognition cameras. Dedicated systems have been developed for this purpose using special ANPR (Automatic Number Plate Recognition) cameras [3]. There are certain areas where these systems are not practical, too heavy or too expensive to use. There are many challenges involved in number plate recognition. The number plates may differ in size, shape, text format and color. Also the environmental factors such as light, illumination, dirt affects the result.

Three main steps of vehicle identification are number plate detection, character segmentation and character recognition [4]. Input to the number plate detection is the car frame captured from video and output is the portion of the frame containing the number plate. In character segmentation step the characters are divided into separate images. After character segmentation, feature extraction is used to extract the relevant features of the characters for recognition purpose.

Feature extraction is the important step of pattern recognition. The result of whole system depends upon feature extraction step [1]. Therefore it is necessary to select and extract relevant features for improving the performance of the whole system. The main motivation of this work is to analyze the features which are extracted from characters for the identification purpose. The frame involves ample of features which needs to be carefully selected for accuracy purpose. These features are provided to classifier for classification purpose. The paper is organized as follows. Section II discusses the related work, section III describes proposed work for vehicle identification, and section IV describes the number plate detection with result. The paper concludes in section V.

II. RELATED WORK

In the literature many number plate recognition algorithms have been proposed. It is still a challenging task to locate the number plate from different angle and with varying environmental conditions. In the entire procedure of number plate recognition most important and difficult step is reliable detection and isolation of the number plate from complex scene. The detailed survey of the number plate recognition is given in [1].

Rob G. J. Wijnhoven et al., presented a novel system for automatic identification of vehicles for garage door opening. Here recognition of both car and character is done using shape descriptor and linear classifier. Features are extracted from images using Histogram of oriented Gradients and provided to classifier for classification purpose. The accuracy of 90% is achieved using this approach [2].

Kumar Parasuraman et al., proposed the number plate recognition algorithm for Malaysian number plates. Here morphological operations are used for detection of number plate. For segmentation purpose they used filtering, thinning and horizontal and vertical projection [3].

S.Kranthi et al., proposed the feature based number plate localization system to recognize the vehicle number plates. Their study focuses on two main algorithms they are edge finding method and window filtering method for the better development of the number plate detection system [4].

C. Nelson Kennady Babu et al., proposed a method for vehicle license plate identification on the basis of a novel adaptive image segmentation technique. Here a novel method for license plate localization based on texture and edge information is proposed [5]. V. Swetha et al., proposed the system to provide security to the restricted areas. The algorithm consists of vehicle detection, extraction of number plate, classification of vehicle and recognition of character. Here for extracting the plate region smearing algorithm is used [6].

P.Vijayalakshmi et al., proposed the number plate recognition algorithm which uses the Genetic algorithm at two levels for vehicle detection and for number recognition. Here detection is based on contour and shape information. Finally, a feature based matching is adopted for character recognition [7].

Shuang Wang et al. proposed a system using video cameras to perform vehicle identification. They reconstruct an input by using multiple linear regression models and compressed sensing, which provide new ways to deal with feature extraction and robustness to occlusions and misalignment [8].

C.N. Anagnostopoulos et al., proposed algorithm for vehicle license plate identification on the basis of a novel adaptive image segmentation technique i.e. Sliding Concentric Windows and connected component analysis in conjunction with a character recognition. The probabilistic neural network is trained to identify alphanumeric characters from car license plates based on data obtained from algorithmic image processing. Here overall accuracy of 86% is achieved [9].

Anish Lazrus et al., proposed the system for number plate recognition of Indian number plates. Here the images of various vehicles have been acquired manually and converted in to gray-scale images. Here the system achieves the accuracy of up to 98% [10].

Dhiraj Ahuja et al., proposed number plate recognition using wavelets and neural network. Here different wavelets are used for license plate detection and feature extraction of license plate characters. Using different wavelets shape features of license plate characters are extracted and analysis of wavelets is done on the basis of recognition rate and time [11].

Fatih Kahraman et al., proposed license plate character recognition based on the Gabor transform and vector quantization. Gabor filter gives the plate boundary location. Then binary split tree is used in order to extract the exact boundary of number plate. After segmentation is done so that characters become ready for the optical character recognition [12].

Subhradeep Kayal et al., proposed automatic number plate detection using Gabor filter and cross cuts. Here the input image is first convolved with a 2-dimensional Gabor Filter with a vertical orientation so as to filter out the vertical edges. Then a method of 'cross-cuts' is adopted to effectively separate the actual plate region from any region with characters or letters [13].

III. PROPOSED SYSTEM

Feature extraction is the first step in many object detection algorithms. It is the process of generating features to be used in the selection and classification task [4]. Different feature extraction techniques are available for extracting features from frames captured from videos which are used to train the classifier for classification purpose. Different feature extraction methods have been developed in the context of vehicle identification. The proposed system will compare the performance of feature extraction technique such as Histogram of Oriented Gradients, Hough Transform features for vehicle identification provided to classifier for classification purpose. Vehicle identification is generally divided into three steps: Number plate detection, character segmentation and character recognition. After character segmentation step the features of character are extracted for recognition purpose. Figure 1 shows the block diagram of the proposed system.

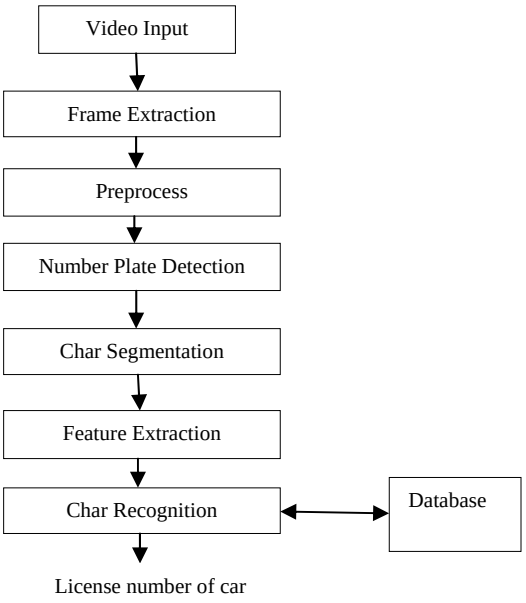


Fig.1. Block diagram of Proposed System

From the given video input, the frame is extracted which contains the number plate of car. After frame extraction, preprocessing of the frame is done to remove the noise from frame. After preprocessing, number plate detection is done using different algorithms explained in section IV. Next step is to segment the characters of number plate. After character segmentation, features extraction is done using different algorithms. In the feature extraction step we apply histogram of oriented gradients (HoG), which is explained as follows.

A. *Histogram of Oriented Gradients (HoG)*

Histogram of Oriented Gradients has many advantages in number plate detection because it is relatively invariant to

local geometric and photometric transformations [2]. In HoG, the image is divided into cells of fixed size. For each cell we compute the local 1D histogram of gradient directions over the pixels of the cell. The combined histogram will form the descriptor. After that the contrast normalization will be performed for making the descriptor invariant to illumination and shadows. Figure 2 shows the steps of HoG. Here the gradient map can be computed by applying 1D point mask in both horizontal and vertical direction. The filter mask [1 0 -1] is used in both horizontal and vertical direction. Next step is to create the cell histogram. Input pixels are spatially quantized into cells of n*n pixels where n is the cell size [2]. Each cell will result in one orientation histogram. To allow for small spatial and orientation shifts, linear interpolation is used in both two spatial and the gradient orientation dimension. To achieve the contrast normalization the cells are grouped into larger spatial blocks and normalize the contrast of each block separately.

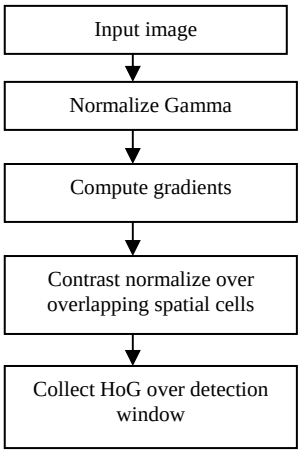


Fig.2. Steps of HoG

B. *Mathematical Model*

Let S be the proposed system

S= {s, e, I, Op, DD, NDD, F_s, F_f, succ, fail,|$\not\in$}

where $\not\in$represents constraints of the system such as number plates are of Indian cars and video is captured from fixed distance,

s = start of system,

e = end of system.

Input video I is represented as {b, r, s, F} where b is bit rate of video, r is frame rate of video, s is the size of frame in pixel dimension format, F is the set of frames in video represented as {c, h, bs}where c is the count of frames in a video, h is the histogram of frame and bs is the bit stream of frame represented as {psc, ts, f_type, G} where psc is picture start code, ts is the time stamp of frame, f_type is the type of frame i.e. I, P or B frame, G is the group of blocks in a frame represented as {gs, gn, M} where gs is the start of group, gn is the group number and M is the macroblock of frame represented as {ad, mv, b} where ad is the address of macroblock, mv is the motion vector and b is block layer which contains the information on the coefficients of pixels. Op is the output which is license number of a car. DD is the deterministic data such as aspect ratio of number plate is within the range of 2 to 5.4, minimum and maximum allowed area for number plate. NDD is the nondeterministic data which is environmental factors such as rain, snow, dirt which affects the result. F_s is the system function which finds the number plate of car from the video and recognizes the number plate.

F_s: I->Op.

F_f represents the set of friend functions as {F_1, F_2, F_3, F_4}, these functions are described as follows.

F_1 is the frame capture function,

F_1: V -> f

F_2 is detection function

where F_2 : f -> p where p is the number plate region of a car represented as (x_{p0}, y_{p0}, x_{p1}, y_{p1}) such that x_{p0} x_{p1} and y_{p0} $y_{p1.}$ p is the region which is set of all neighboring pixels

(x, y) which is continuous element.

Pixel (x, y) belongs to p if there is at least one pixel (x', y') which is neighbor of (x, y).

(x, y) ∈ p if (x', y') ∈ p ∧ (x, y) and (x', y') are neighbors.

F_3 is the preprocessing function which removes the noise from the frame.

F_3 is the function to convert the color frame to gray scale frame represented by following equation,

$F_3 = 0.299*R + 0.587*G+ 0.114*B$ (1)

where R, G, B are Red, Green and Blue components of the corresponding pixels.

$F4$ is the segmentation function which is given by following equation,

$$F4 = \sum_{s=-1}^{1} \sum_{t=-1}^{1} w(s,t) f(x+s, y+t) \quad (2)$$

where $w(s,t)$ is a sobel filter, $f(x,y)$ is the input frame.

Succ is the success which is achieved when access is provided to authorized cars. Fail is the failure when the car is not identified correctly because of damaged plates or due to environmental conditions like rain, fog, dirt etc.

IV. NUMBER PLATE DETECTION

Number plate detection is the key step of vehicle identification system. It affects the result of whole system. The goal of this phase, given a frame captured from input video is to produce the region with high probability of containing the number plate area. We have performed the experiments using QT tool and OpenCV image processing libraries. The version of Qt used is 4.7 and of OpenCV 2.4. QT is a cross platform application framework used for developing application software. It runs on major desktop platforms and some mobile platform. Figure 3 shows the input frame captured from the video for number plate detection.

A. *Preprocessing*

Preprocessing of frames involves removing the noise from frames. When the input frames are captured from video,it may involve noise which affect the recognition accuracy. This noise should be removed before further

processing. Preprocessing improves the quality of frames by removing the noise [16]. Preprocessing involves conversion of color frame to gray scale frame and applying the median filter. The following equation is used to convert color image to gray scale image.

Gray(i) = 0.299*R + 0.587*G+ 0.114*B

B. *Vertical Edge Detection*

Edges helps to characterize the boundaries therefore they are important for processing images. Edges are present in areas where strong intensity contrast are present [16]. In this system we have used the Sobel vertical edge detection [15] to find out the region which has high pixel varience.

C. *Morphological Operation*

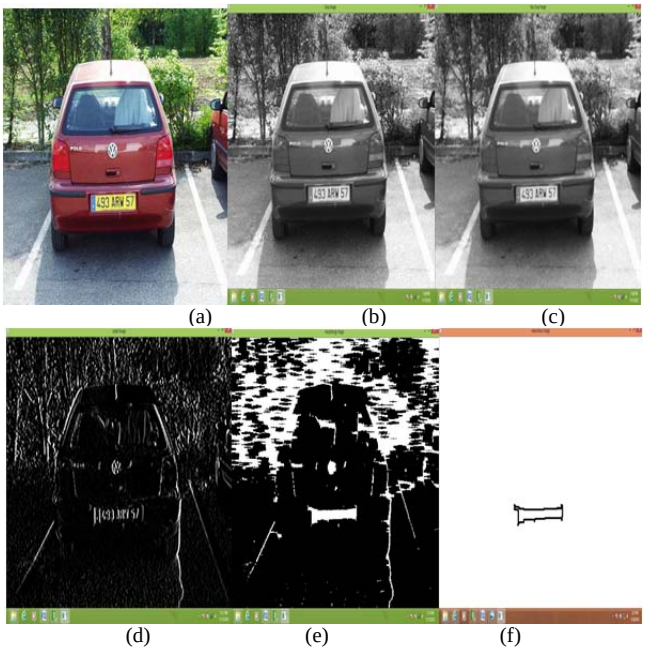
The main objective of this step is to find out the rough location of number plate. It looks for objects having specific size and aspect for each connected component in the image. Here two algorithms called Erosion and Dilation [15] are used. The order between these algorithms is very important since the reverse process would give a completely different result [14]. The output of this step is to find all the possible location of number plate area in image.

D. *Connected Component Analysis*

Connected component analysis is used to find the exact location of number plate. The number plate of car has certain properties which can be used to detect the number plate. Properties such as aspect ratio, width of number plate and total number of pixels present in the number plate can be used to extract the number plate area [14]. Here we have used aspect ratio of number plate. Aspect ratio of number plate is defined as ratio of width of number plate to its height. Inverse of aspect ratio for any number plate should be less than one for any number plate. Hence all the regions that do not satisfy this property can be rejected and we get the exact number plate location. This number plate location can be further used for character segmentation and character recognition to identify the car.

V. EXPERIMENTAL STUDY AND RESULTS

We have performed experiments using Qt tool and OpenCV libraries. The version of Qt used is 4.7 and of OpenCV 2.4. Qt is a cross platform application framework used for developing application software. It runs on major desktop platforms and some mobile platform. OpenCV is the library of programming functions which focuses mainly on image processing. For experimentation we have used the database of large number of images of dimension 512×409. Figure a shows the original image used for number plate detection. Figure b is the result after converting to gray scale image. Figure c shows the result of median filter. Figure d is the result after applying sobel vertical edge detection. Figure e is the result after applying morphological operations. Figure f shows the final result, it shows the identified number plate area. Table 1 shows the pixel values of four input images and preprocessing stage image pixel values. This table shows how the values changes from input image to output images at different stages. First color image is converted into gray scale image, after that median filter is applied, after sobel vertical edge detection is applied, after morphological operations are applied and finally we get the identified number plate area.



(a) (b) (c)

(d) (e) (f)

Figure 3 a) Input Image 1, b) Gray Scale Image, c) Median filtered Image d) Edge Detected Image, e) After applying Morphological operations, f) Plate Detection.

Table 1 Pixel Values of input images and result images

Preprocessing stage values	Image 1	Image 2	Image 3	Image 4
Input Imge values	44,112,71,37,105,64,55, 12180,55	25, 65, 40, 19, 58, 33, 12, 42, 23	65, 143, 119, 102, 193, 167, 102, 215, 187,	89, 105, 111, 89, 105, 111, 88, 105, 108
Gray scale image values	92,85,101,101131,109,91,107,112,99	53, 46, 33, 43, 60, 44, 29, 47, 28	127, 175, 194, 91, 209, 186, 195, 45, 181	105, 105, 104, 102, 103, 104, 104, 102, 103
Median filtered image values	93,93,101,103131131,106,97,107,112	46, 44, 43, 43, 44, 34, 34, 29, 29	127, 164, 175, 187, 178, 183, 186, 183, 159	104, 104, 104, 103, 104, 104, 104, 104, 103
Edge Detected image values	17,17,48,10472,0,0,32,65,17	0, 0, 8, 5, 0, 0, 0, 0, 0, 2	0, 154, 106, 22, 4, 16, 0, 0, 0, 0	0, 0, 0, 0, 4, 2, 2, 0, 0, 0
Morphological image values	255,255,255,255,255,255,255,255,0,0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0	255, 255, 255, 255, 255, 255, 255, 255, 255,	0, 0, 0, 0, 0, 0, 0, 0, 0, 0
Identified number plate area values	255,255,255,255,255,255,255,255,255,255	255, 255, 255, 255, 255, 255, 255, 255, 255, 255	255, 255, 255, 255, 255, 255, 255, 255, 255, 255	255, 255, 255, 255, 255, 255, 255, 255, 255, 255

VI. CONCLUSION

Feature extraction is the key point of pattern recognition. A reliable feature extraction technique is required for improving the accuracy of classification. The system proposes the number plate detection system for car identification. The number plate area is detected correctly using different algorithms. In the future we are planning to use feature extraction algorithms for identifying the characters on the number plate and checking the performance of feature extraction algorithms.

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