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AN APPROACH FOR AUTOMATIC VEHICLE PLATE RECOGNITION IN UNCONSTRAINED ENVIRONMENT

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Abstract

Automatic vehicle plate recognition or AVPR is becoming very popular and the most challenging topic of research that helps in developing intelligent transportation system (ITS) in a city or country. The purpose of this project is to develop a real time AVPR system which recognizes the vehicle plates at the gate entrance, roads, border crossing and restricted areas. The proposed system is based on the vehicle images captured by the digital camera. This system has two main process namely Enrolment process and Identification process. Since vehicle plate standards are not strictly practiced in India, localization of license plate from the vehicle image is the most difficult task due to the huge variations in size of vehicle plate, location of number plate, background and foreground color, noise and non-uniform illumination of license plate due to varying lighting conditions. This system can be used in various applications such as vehicle surveillance, border security, toll collection, monitoring road traffic, tracking vehicle during traffic signal violation and automatic ticketing of vehicles at car parking area. The proposed system is designed to work with images captured during night time, under various illumination, camera angle and weather conditions. This system works with high recognition rate and efficiency and less computational time.

Keywords: Enrolment process, Feature Extraction, Identification process, Image Enhancement, Image Recognition and Number Plate Localization.

1. Introduction

Due to many possible commercial applications of automatic vehicle plate recognition, huge research work has been done in this area. In 1976, the Police Scientific Development Branch in the UK started developing a system that was up and running in 1979. In 1981, the first arrest due to a stolen car being detected by this system was made.

In India, the district level regional transport office (RTO) of the respective states provides a unique number for a vehicle during the registration of vehicles. This unique number is written on the license plate placed in front and back

of the vehicle. The vehicle plate has combination of alphabets and numbers as shown in Figure 1. It starts with two alphabets of a state code followed by two digit representing the district region code. Then it has some letters followed by a four digit registration number. The license plate can be used to uniquely identify the vehicle and its owner by using vehicle plate number the complete information about the vehicle and the vehicle owner can be gathered.

Figure 1: Sample for Indian Vehicle plate

Table-I: Comparison on Recognition rate of different methods.

Methods	FAR	FRR	Recognition Rate
CCA	0.03	0.05	0.912
Morphology	0.02	0.06	0.92
Vertical edge detection	0.05	0.02	0.925
Complete de-blurring	0.02	0.04	0.93
Proposed method	**0.011**	**0.03**	**0.95**

The number of vehicles on roads has been increased in the country due to the increase of population. So there is a need for monitoring these vehicles on the roads and in different places for various reasons. The existing surveillance camera can only be able to capture and record the vehicle image or video. But there is no processing is done followed by the recorded image or video. If there is a need to search for a particular vehicle, then the captured image will be taken out and the human operator will carry out the searching process. It is a time consuming process. In some places, the vehicle entry will be made by the human operator during the entry for future reference. But it is difficult to monitor and record the vehicle number manually when there is vast number of vehicles are entering. So, the surveillance camera can only monitor the vehicles but lacks the identification capability. Hence the need for automatic vehicle plate recognition (AVPR) system has been raised. By deploying AVPR system, the transportation system can be greatly improved. Some algorithms are based on identifying the vehicle plate using the image features such as the shape, colour, or height-to-width ratio. The performance of these algorithms is very sensitive to changes in environmental conditions such as light or weather conditions that affects the quality of image features. The edge detection is a largely used method in the image processing. It is widely incorporated in the applications such as object

detection. It is used for detecting the rectangular license plate by finding the horizontal and vertical edges. A popularly known edge detection methods are Canny edge detection and Sobel edge detection.

The technique of determining a threshold value using Canny edge detection method and PANDA framework was proposed in [1] to extract character portions and recognize the characters in license plates. The Canny edge detection is used to find the shape of each character in the vehicle plate. The PANDA framework is used to find and recognize the characters by comparing two patterns. If the pattern does not exist in the dataset it adds the pattern into the dataset for future reference. This method determines a threshold value corresponding to change of character domain and brightness. By this approach, the recognition rate is improved considerably. Edge detection is based on the fact and assumption that the vehicle plate region will contain higher edge density compared to the remaining areas in the image. Hence we can say that the vehicle plate possesses rich edge information. The distance and view angle has a restriction on implementing the edge detection algorithm. The estimation of vertical edge density utilizes a low threshold to avoid missing plate edges for edge detection. The usage of threshold value affects the computational time and low system performance. The edge detection method has a very simple implementation. The less complexity of the algorithm makes it suitable for real-time applications. However, in the edge detection method, the detection rate is affected by the quality of the image such as lowest resolution and blurring of the vehicle plate image. The edge detection method fails when applied to the complex images where the boundary of the license plate is not clear or distorted or the image contain lot of vertical and horizontal edges. It needs a continuity of the edges, if any break in the edges then the algorithm fails to detect the vehicle plate. The unwanted edge information such as noise edges is generated due to the complexity of the scene such as the background and the objects.

Many false candidates are generated during the edge detection process. Hence, the morphological transformation [2] is applied after edge detection to obtain the license plate region. The mathematical morphology consists of two steps known as erosion and dilation. Among the false candidates, the right license plate region can be obtained if it has the real plate dimensions and many vertical edges. The vertical edges are well known for the vehicle plate region because of the contrasting strokes of vehicle plate characters. Hence the false candidate generation is rejected by using edge detection with the morphological transformation. The morphological operation performs better in the complicated background. The combination of edge detection with morphology operator produces good result but it fails to identify vehicle plate when the images are too blur and has poor lighting conditions.

To overcome the problems encountered in edge detection method, colour-based image processing method has been proposed in [3]. In this paper, the gray image is converted to binary image by adaptive threshold. The license plate is localized by using some prior knowledge of the license plate. An accurate edge detection process based on the colour information of the license plate is used for license plate segmentation. The algorithm works for complex, noisy and in poor illumination and the algorithm is robust with high performance. The accuracy of the vehicle plate system in the images with the complex background is enhanced by analysing the colour in the image. It is used for the foreign license plates which follows a standard format for the license plates. For example, license plates belonging to the European Union member countries have a unique colour format. In a country like Iraq, the regional license plates have been separated from each other. So, it has poor recognition rate in countries where the vehicle plate is not standardized.

Ryung Lee et al [4] proposed an automatic recognition of a car license plate using colour image processing. The RGB input image is converted into HLS colour using HLS colour model. The neural network method is used for colour extraction by classifying the colour of each pixel. The colours present in the Korean vehicle plate are green, red, and white. These colours are projected horizontally and vertically to find the highest colour density region which can be found in the vehicle plate region. Initially the background colours of a vehicle plate are extracted from an image. Since the proposed method does not depend on line information of a plate it is very robust to boundary information. Also, this method is strong enough to deal with a car image which has many similar regions with a plate. The extraction of vehicle plate using colour information, allows to identify the inclined and deformed plates. But, defining the pixel colour using the RGB value is very difficult, particularly in different illumination conditions. The HLS colour model is very sensitive to noise. It also suffers from wrong detection, particularly when some region of the image have the same license plate colour such as the car body and background objects. This method fails to work when vehicle body and vehicle plate have same colour. It is also not suitable in countries where multiple colours are used.

For identifying the vehicle plate colour, a Genetic algorithm (GA) was presented in [5] as a search method. A GA is used to find the upper and lower thresholds for the plate colour from the training images with various lighting conditions. A special function is employed to find the relation between the average brightness and thresholds. First the average brightness is determined from the input image, and then the lower and upper thresholds are found. If any pixel with a value between these thresholds is identified, then it is marked. If the connectivity of the marked pixels is

in the rectangular shape with the same aspect ratio of the vehicle plate, then that area is considered as the vehicle plate region. Due to complexity of analysing the colour in the vehicle plate image, this method has a very long execution time. When there is a constant lighting condition, this technique performs well but the performance gets reduce when there is various illumination. But in real-time application the vehicle plate images can be obtained with various lighting illumination. Hence, this technique is country specific because each country will have different colour code for vehicle number plate.

The vehicle plate recognition methods are generally based on colour or shape, they are inefficient at detecting various vehicle plates with varying colours and shapes. This is due to the nature of the plate which is texture-based. So, the texture-based feature extraction methods such as SVM should be there. Hough Transform and Gabor Transformation has been proposed. Tran Duc et al [6] proposed a Hough transform method that is combined with contour algorithm. It uses the contour algorithm to detect the closed boundaries of objects in the edge extracted binary image. These contour lines are transformed to Hough coordinate to find two interacted parallel lines, that is one of 2-parallel lines holds back the other 2-parallel lines and establishes a parallelogram-form object, that are considered as a vehicle plate candidate. Since there are few pixels in the contour lines, the transformation of these points to Hough coordinate requires much less computation.

Hence, the speed of the algorithm is improved significantly without the loss of accuracy. However, this technique may detect the headlights or windscreen wrongly as vehicle plate candidates. This is because they have parallelogram shape. It has high execution time. When it is applied to a high resolution binary image, it undergoes too much computation.

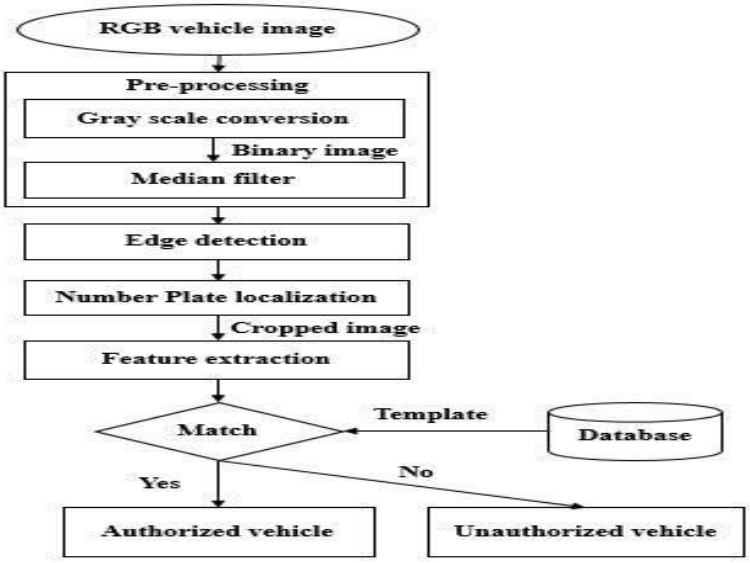
So, it is difficult to use in the real-time traffic management systems. Rajesh et al [7] proposed a Connected Component Analysis (CCA) method to detect the vehicle plate region. CCA is useful for simplifying the detection task, since it labels binary image into several components based on their connectivity. Based on the problem one can decide on the selection of finding the connected components using 4-adjacency or 8-adjacency of pixels connectivity. Spatial measurement is a measure of spatial characteristics of a connected component such as area, orientation, aspect ratio etc. and filtering is done to eliminate unrelated or unwanted components.

When Connected Component Analysis is combined with spatial measurement and filtering produces better result in number plate detection. But this method also fails to recognize the vehicle plate region when there is a region in the image similar to the vehicle plate region.

2. Methods

The AVPR system has two main process namely Enrolment process and Identification process. Figure 2 shows the overall architecture of the AVPR system. This system consists of five main modules namely,

- Image Acquisition
- Pre-processing or Image Enhancement
- Number Plate Localization
- Feature Extraction
- Image Recognition



- **Figure 2: Overall Architecture of the system.**

A. Image Acquisition

The first step is to capture the image of a vehicle crossing the entrance using the electronic devices such as digital camera or from database according to the requirement of the system. It is necessary to place the camera at a particular distance away from the vehicle to acquire the fixed area of the vehicle plate. To get the good quality image taken during the day time as well as night time, infrared cameras can be used. To avoid bad weather conditions, proper lighting facility can be used.

B. Pre-processing

After the acquisition of image, pre-processing of an image is done. When an image is acquired, there may be a lot of irrelevant information or impurities such as noises, holes, dirt particles and background can be present in the image that affects the quality of the image. Hence it is necessary to enhance the quality of an image.

Gray scale conversion: It involves conversion of color image into a gray scale image as shown in Figure 3. The input image consists of many colors and therefore the image is processed initially to enhance the image quality. So the image with different colors is converted from RGB image to gray scale image.

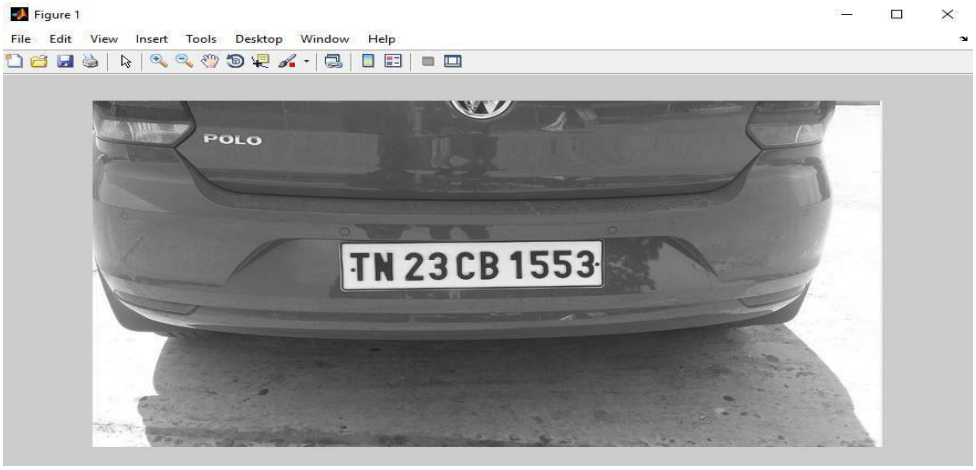


Figure 3: Gray scale image.

Median Filter:

When an image is acquired, there may be various type of noise such as speckle noise, salt and pepper noise etc. This noise cannot be eliminated in gray processing. It largely affects the recognition rate of the system. So, it is necessary to remove the noise. Among many filters available namely Wiener filter, Median filter, Laplacian filter, Average filter, and Gaussian filter, the Median filter performs well for removing noise on vehicle plate region. Hence, the noise is removed using Median filter as shown in Figure 4 where the original pixels of input image is replaced by the median of pixels.

Figure 4: Image after applying Median filter.

Edge Detection:

Morphological operators are used to enhance the edges in the image. The localization of vehicle plate can be done only if the edges of the plate is clearly visible. The Dilation known as opening operation and Erosion known as closing operation is performed on noise filtered image. Dilation is the process of adding pixels to the boundary and

Erosion is the process of removing pixels from boundary performing both horizontally and vertically by using the disk as a structuring element. After subtracting opened image and closed image, we get the vehicle plate region as connected region with some unwanted regions as shown in Figure 5.

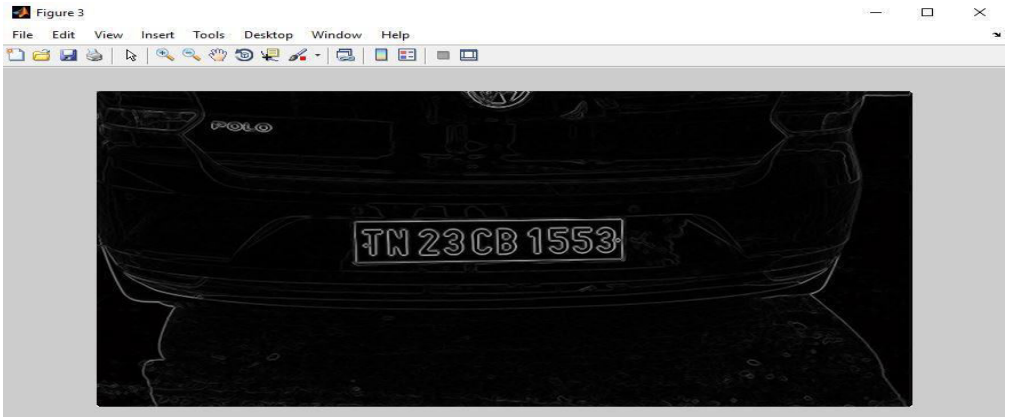


Figure 5: Edge detected image.

After performing dilation and erosion, the holes present in the edge detected image is filled as shown in Figure 6.

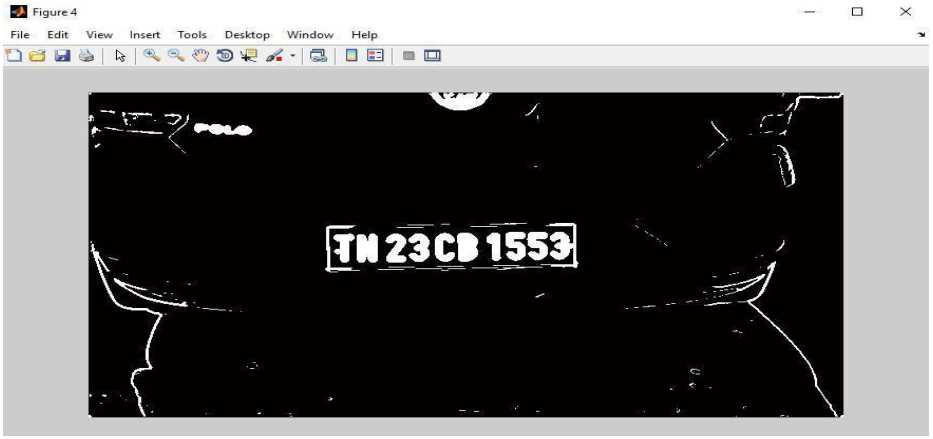


Figure 6: Image after filling holes.

The unwanted regions in the vehicle image can be removed using the threshold value after filling the holes as shown in Figure 7. Thus, Morphological operators known as dilation and erosion are used to detect the edges of the vehicle plate.

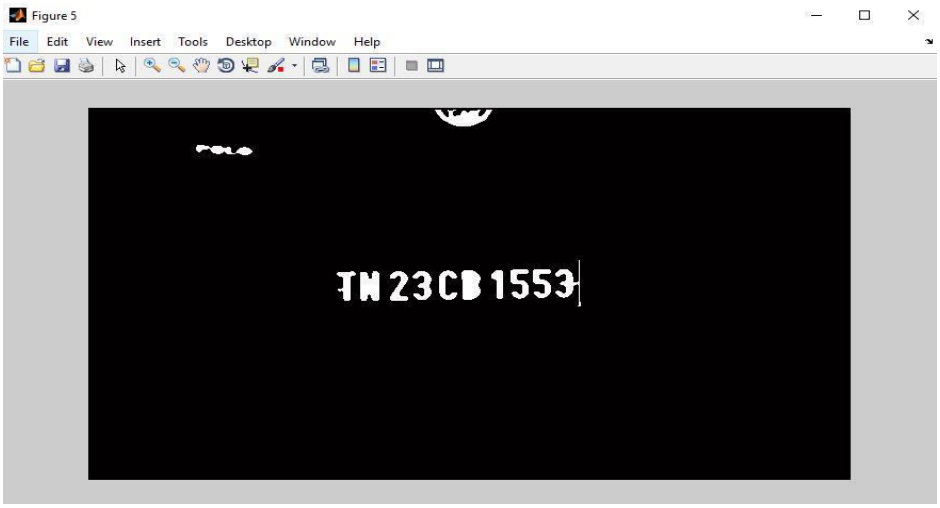


Figure 7: Thresholded image.

C. Number Plate Localization

The various parameters are necessary to be calculated to find the location of the vehicle plate. The format of license plate consists of white or yellow background and vehicle plate number written in the black colour. Using these colour information, the region of vehicle plate can be identified easily. First, the pre-processed image pixels are defined with RGB value by comparing with the original input image as shown in Figure 8.

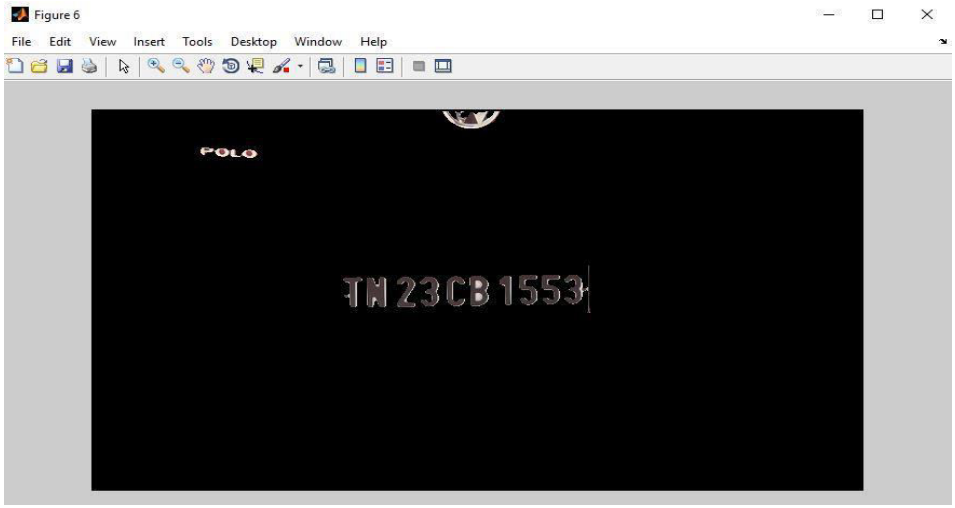


Figure 8: Image after applying color information.

Now, the processed image will have the vehicle plate number highlighted in black along with other parts of the vehicle in various colours. By using this colour information in the processed image, the regions in the black colour are retrieved by eliminating the regions in other colours. Now, the image will contain the vehicle number plate with some vehicle parts in black colour as shown in Figure 9.

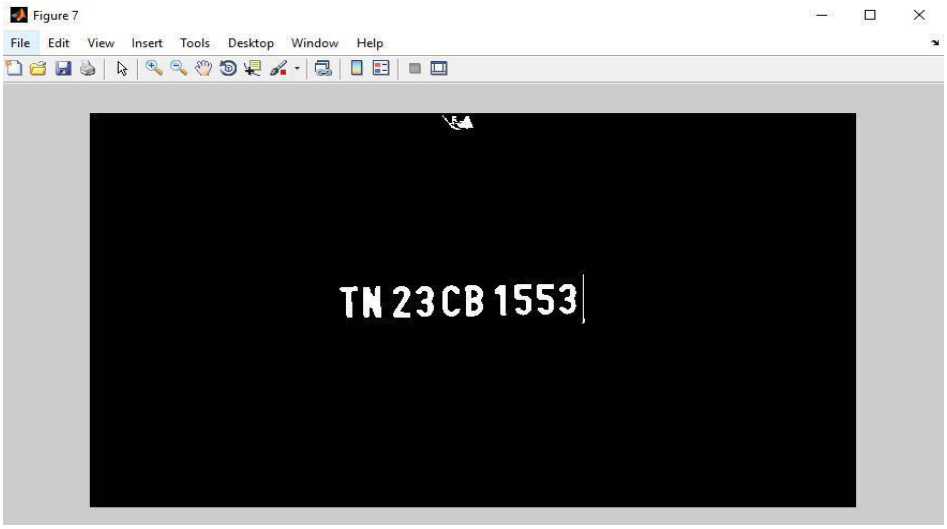


Figure 9: Image after extracting black color region.

This extra unwanted regions are eliminated by using the combination of bounding box and box plot analysis. The connected objects are identified by creating a bounding box which is a rectangle box around the object. The height and width of characters in vehicle plate number will be same. By using this information, the bounding box is created around the characters as shown in Figure 10 and the regions other than vehicle plate number are eliminated.

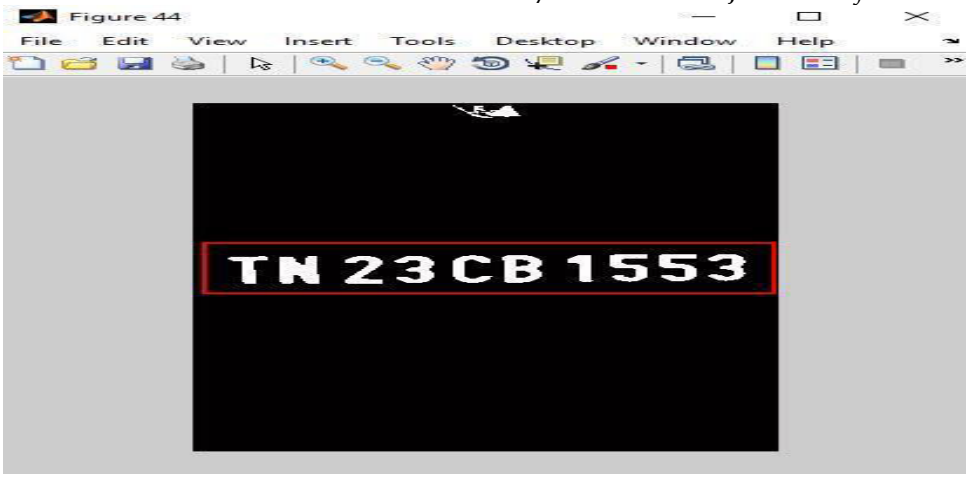


Figure 10: Number plate Localization

D. Feature Extraction

The next step is to extract the features of vehicle plate number from the cropped vehicle plate and store it in the database. The vehicle plate recognition is performed well if the plate characteristics or features are extracted in well-organized way. Each characters in the vehicle plate number will have its own shape and style. By using this information, the features of characters in the number plate are extracted and stored as template in the database during the enrolment process. The extracted features of characters in testing image as shown in Figure 11 is used to compare with the templates in the database during the identification process. During the enrolment process, the vehicle plate number and the owner details are stored along with the captured template. These information in the database is used to match and recognize the authorized vehicle.

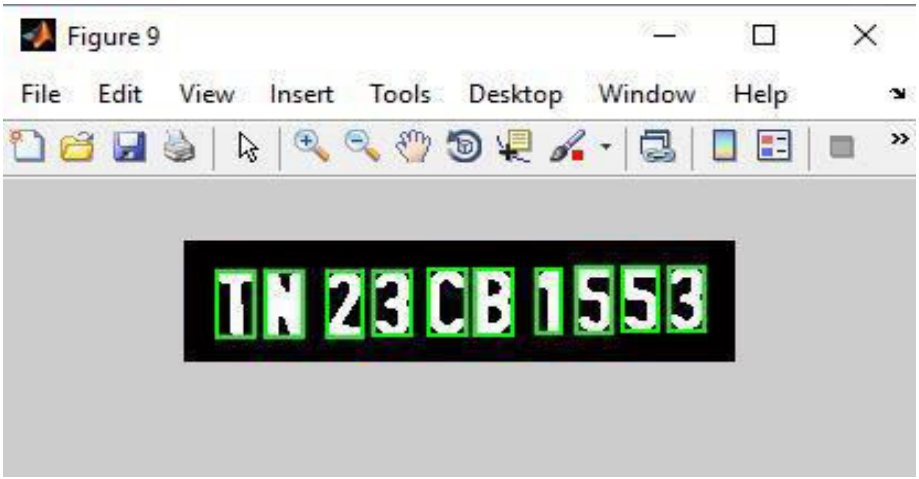


Figure 11: Feature Extraction

E. Image Recognition

The final step of this system is to match the template features to the features of the testing vehicle plate image. A vehicle plate is recognized in an image by matching the testing image feature to the templates in the database and then finding the candidate matching features using the Correlation distance measure. To perform reliable recognition,

it is important that the features extracted from the trained image be detectable even captured during night time, under changes in camera angle, noise, illumination and weather conditions.

When the correct match is found, the system displays the message that it is an authorized vehicle along with the vehicle plate number and the owner information to the system operator. When the match is not found, the system displays that it is an unauthorized vehicle.

3. Results And Discussion

The database is created with the vehicle images that is captured on the roads and Car Parking area in VIT University. The images are captured during the day time as well as night time and under various camera distance, camera angle, illumination, background and environmental conditions. The vehicle plate extraction needs extremely high accuracy when working on images of busy roads or parking areas. The AVPR system achieves about 95% of accuracy. It has been tested with 85 vehicle images consisting of both Indian vehicle plates and foreign vehicle plates.

Table I shows the related work comparison with our work.The result shows that the system robustly detects and recognizes the vehicle plate captured during day time, night time, under different illuminations, camera angles and various weather conditions i.e. rainy days, sunny etc.

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4. Conclusion

In this paper, a simple and efficient method was proposed for automatic Vehicle plate recognition. The proposed method is mainly designed for real-time Indian vehicles number plate but it also works well for foreign number plates. The AVPR system identifies the authorized vehicle by recognizing the vehicle plate number. This system is tested with vehicle images taken during night time, under different illumination and various weather conditions i.e. rainy days, sunny etc. It recognizes the authorized vehicle and displays the vehicle plate number along with the owner

information. This system greatly achieves about 95% of accuracy. It reduces the overall cost and improves the efficiency. This system can be deployed in various applications such as vehicle surveillance, border security, toll collection, monitoring road traffic, tracking vehicle during traffic signal violation and automatic ticketing of vehicles at car parking area.

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