Automatic License Plate Recognition

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***Abstract* – Automatic License Plate Recognition (ALPR) is a mass surveillance system that captures the image of vehicles and recognizes their license number. ANPR can be assisted in the detection of stolen vehicles. One of the most useful techniques in track management, speed control and security improvement in big cities is Automatic License Plate Recognition (ALPR). This system is designed for the purpose of the security system and is based upon the logic of image processing system. Further the processed data is used for further processes like storing, allowing vehicle to pass or to reject vehicle. LPR is an image processing technology which uses number (license) plate to identify the vehicle. Since the identification is done by using the license plate information, hence there is no need for any additional hardware to be installed on vehicles. The system is implemented on the entrance for security control of a highly restricted area like military zones or area around top government offices e.g. Parliament, Supreme Court etc. It is observed from the experiment that the developed system successfully detects and recognize the vehicle number plate on real images.**

Keywords- Image acquisition, Pre processing(Gray scale & Median filtering), Plate region extraction, Segmentation of Character in the extracted number of plate,Optical Character Recognition.

I. INTRODUCTION

Massive integration of information technologies into all aspects of modern life caused demand for processing vehicles as conceptual resources in information systems. License Plate Recognition Systems are utilized frequently for access control in buildings and parking areas, law enforcement, stolen car detection, traffic control, automatic toll collection and marketing research [1]. In entrance gate, number plates are used to identify the vehicles. When a vehicle enters an input gate, number plate is automatically recognized and information is stored in database. Hence, a black-listed number is not given permission to enter ,if found, after compiling the newly stored data with the older data stored. Later on when the same vehicle exits the place through the gate, number plate is again recognized and paired with the earlier one stored in the database and it is taken a count to ensure that the vehicle has left the place. For example, this technology is used in many companies to grant access only to vehicles of authorized personnel.License plate locations are usually found based on their characteristics. These characteristics can include the color, size, grayness [2], and rectangularity.Character identification planned is based on lines, alphanumeric character aspect ratio, the gaps between the characters and the organization of the characters. Some of the proposed methods for character separation include morphology [2] and projection [3]; both of which have their own advantages and disadvantages. Even though ALPR system is available in other system is available in other countries also still research needs to be done as the style and font of number plate for different countries is different [4] for example in Malaysia.

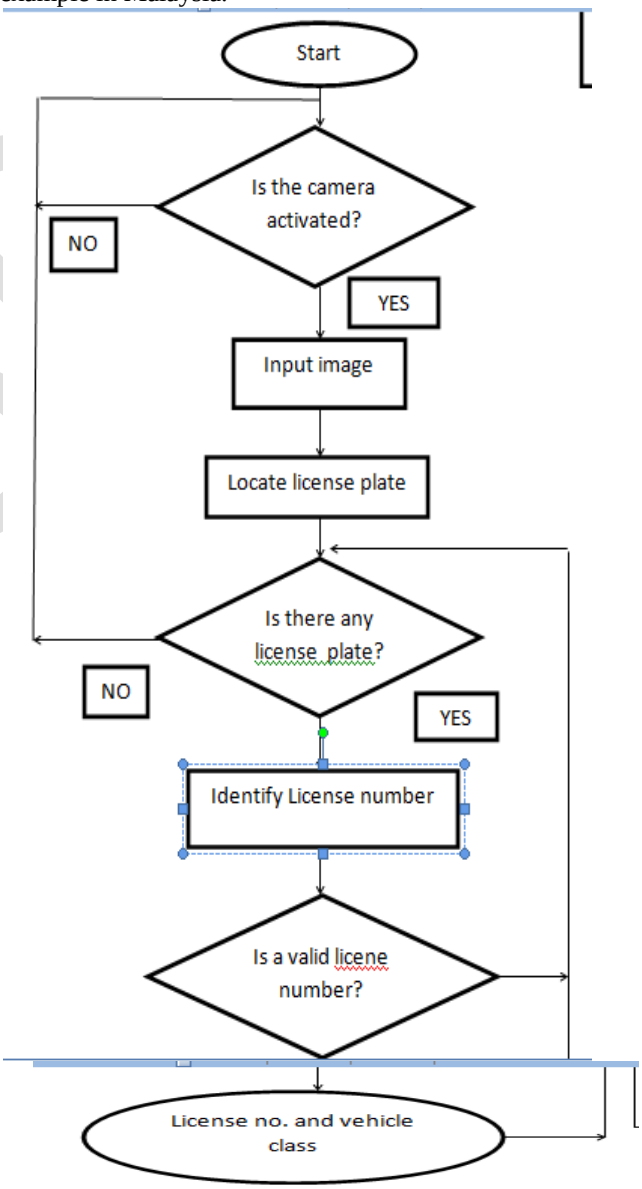


Fig. 1 A Flowchart of automatic license plate recognition

II. THEORETICAL FRAMEWORK

The Basic flow of ANPR algorithm is as shown in Fig.2

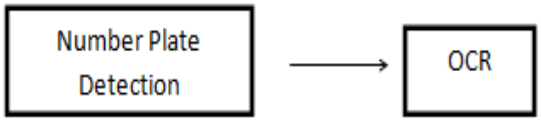


Fig. 2 Basic flow chart of ANPR algorithm

Many approaches have been researched in this area. Table I and Table II illustrates the few methods that are used.

TABLE I
NUMBER PLATE AREA DETECTION METHODS

Methods	Description	Disadvantage
Edgedetection	Number plate has high magnitude in edges [5]	Background interference creates highmagnitude in edges
Colourcontrast	Black and white number plate has highcolour contrast [6]	Not applicable for number plates withcolours

TABLE II
OCR METHODS [6]

Methods	Description	Disadvantages
Correlation [7]	Straight forward and reliable	- Not tolerant to fontdifference and tiltstore all templates -Huge storage is needed to store allTemplates
Structure analysis [8]	tolerant to font difference and tilt	Complex analysis is needed to differentiate allcharacters
Neural networks[9]	tolerant to font difference and tilt	High investment to train system

III. METHODOLOGY

Software model is the main and most important portion of this system. The software model use series of image processing techniques which are implemented in MATLAB. The flow chart of license plate recognition system implementation in this work is shown in the following figure. There are various steps in this approach and these are implementationin MATLAB.

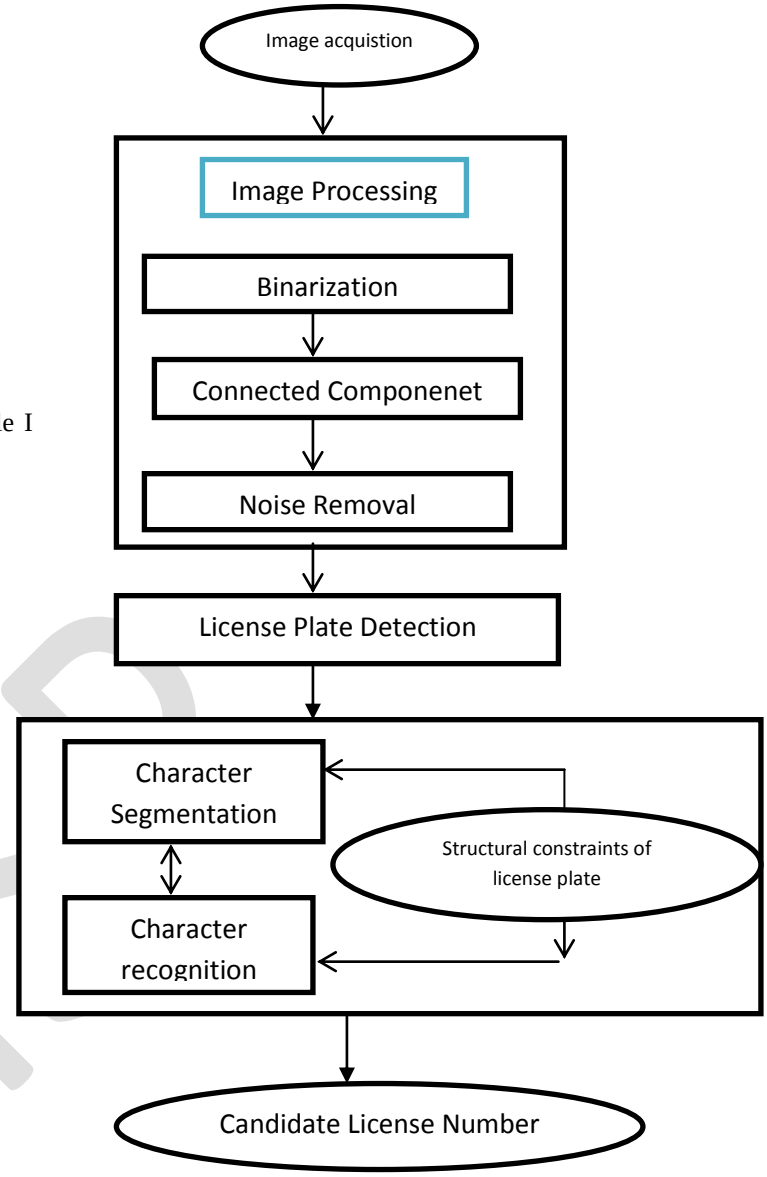


Fig.3 Flowchart for License Plate Recognition

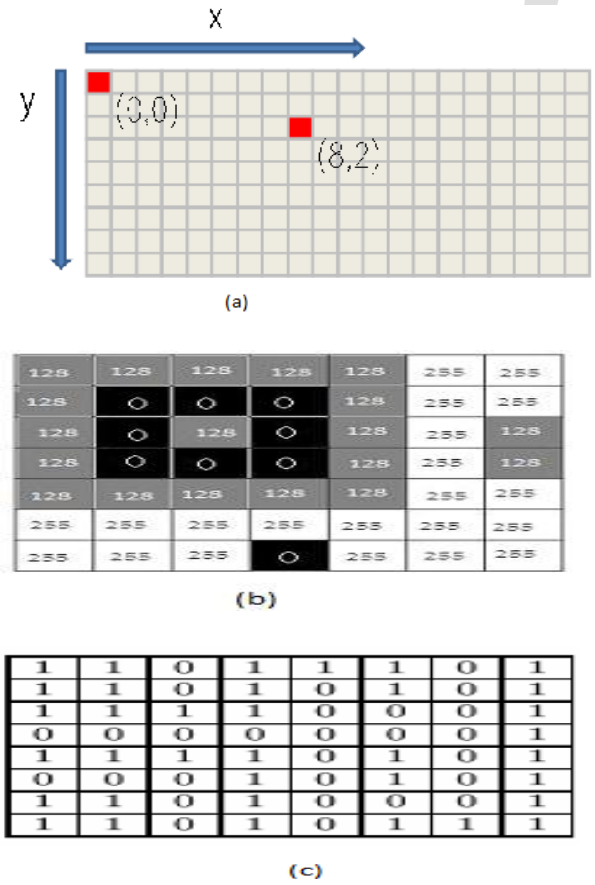
A. Capture image(Image acquisition)

The first step is the capturing of an image using electronic devices such as optical (digital/video) camera; webcametc can be used to capture the acquired images. For this project, vehicle images will be taken with a Panasonic FX/Nikon digital camera. In this project pre-captured image will taken. The images will be stored as colour JPEG format on the camera. Next, we might proceed in using the Matlab function to convert the vehicle JPEG image into gray scale format Input of this system is the image captured by a camera placed at a distance of 1-2 metres away from the vehicle as shown in following Fig.4

Fig.4 Original image [car. Jpg]

Introduction to images

An image is a matrix with X rows and Y columns. It is represented as function say f(x, y) of intensity values for each color over a 2D plane. 2D points, pixel coordinates in an image, can be denoted using a pair of values. The image is stored as a small squared regions or number of picture elements called **pixels** as shown in the following figure5:



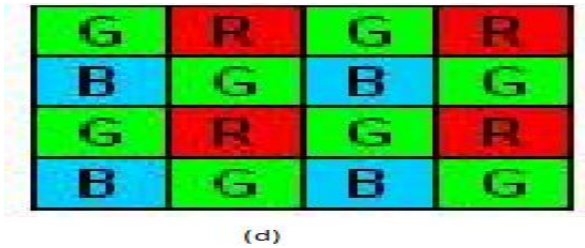


Fig 5: (a) image matrix (b) gray scale image matrix (c) binary image matrix (d) colored image with rgb representation

In digital image, pixels contain color value and each pixel uses 8 bits (0 to 7 bits). Most commonly, image has three types of representation gray scale image, Binary image and colored image as shown in figure 8 (b), (c), (d) respectively. Gray scale image, figure (b), calculates the intensity of light and it contains 8 bits (or one Byte or 256 values i.e. 28 = 256). Each pixel in the gray scale image represents one of the 256 values, in particular the value 0 representsblack, 255 represents the white and the remaining values represents intermediate shades between black and white. The images with only two colors (black and white) are different to these gray scale images. Those two colored images are called binary images (c). So binary representation of the images does not contains shades between black and white. Color images, (d) are often built of several stacked color channels, each of them representing value levels of the given channel. For example, RGB images are composed of three independent channels for red, green and blue as primary color components. The color image contains 24 bits or 3 bytes and each byte has 256 values from 0 to 255.

Image Acquisition is the first step in an LPR system and there are a number of ways to acquire images, developed a sensing system, which uses two CCDs (Charge Coupled Devices) and a prism to split an incident ray into two lightswith different intensities. The main feature of this sensing system is that it covers wide illumination conditions from twilight to noon under sunshine as well as this system is capable of capturing images of fast moving vehicles without making them blurr. After acquiring the image, the very next step is to convert the observed image into the gray scale image. Pseudo code to convert an image to a gray scale:

STEP1 : Load the image
STEP2 : Retrieve the properties of image like width, height and channels
STEP3: Get the pointer to access image data
STEP4: For each height and for each width of the image, convert image to gray scale by calculating average of r,g,b channels of the image convert to gray scale manually
STEP5 : Display the image after converting to grayscale.

The flowchart shown in the fig.6 below describes the algorithm to convert a captured image into a gray scale image.

Binary images

Threshold is a quick way to convert gray scale image into binary image (a combination of black and white pixels). i.e.

binary image can obtained from gray-level or color image. Here in this paper we have considered the gray level image. The binary image pixel values are obtained using the characteristic function as shown below:

b(x, y) = 1 if g(x, y) < T

b(x,y) = 0 if g(x, y) >= T

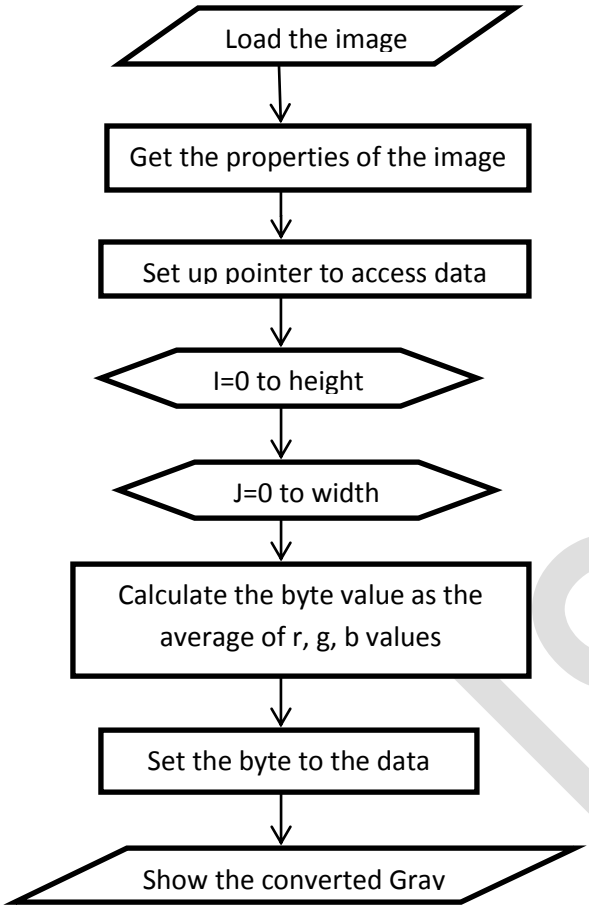


Fig. 6 Flowchart to convert image to grayscale

Proposed Algorithm to convert gray image to binary image is explained in the fig.7:

STEP1 :load the image

STEP2 :setupthreshold,type ,max value

STEP3: convert gray image into binary image

STEP4**:** show the image after the conversion is done to binary**.**

B. Pre-processing

After the acquisition of image, pre-processing of image is done. When an image is acquired, there are certain kind of noises present in an image which affect the recognition rate greatly. So these noises are required to be removed from the images.

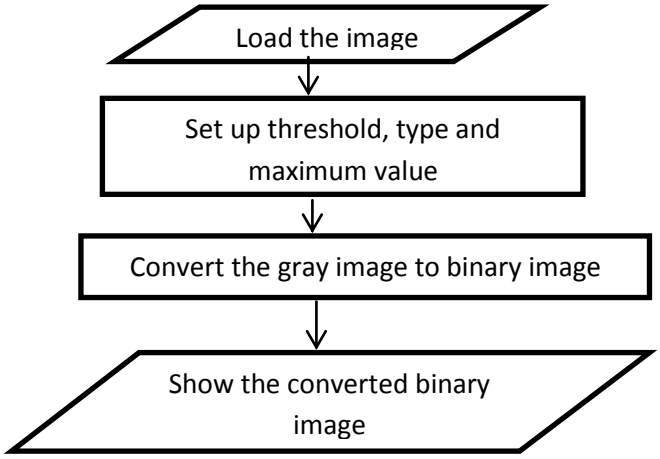


Fig.7 Flowchart to convert image to binary

1) Gray Processing:

It involves conversion of color image into a gray image. The method is set on different color transformation.In RGB format, each Pixel has three colour components: Red, Green, and Blue. In pre-processing step, the colour image is given as an input and it is converted into grayscale image. The first step to digitize a "black and white" image composed of an array of gray shades is to divide the image into a number of pixels, depending on the required spatial resolution. This range is represented in abstract way as a range from 0 (black) and 1 (white), with anyfractional values.According to the value of R, G, B in the image, it calculates the value of gray colour and simultaneously obtains the gray image.

Fig 8. Gray scale image

Fig.9 Binary image

2) Median Filtering:

When images are acquired, there are lot of noises associated with the image. The noise is impossible to be eliminated in gray processing. To remove noise from the image 'median filters' are used so that image becomes free from noise. Noise removal is a mandatory step in License plate recognition system because it greatly and directly affects the recognition rate of the system.

Fig. 10 Filtered Image

C. Edge Detection

The purpose of edge detection is significantly reducing the amount of data in an image and preserves the structural properties for further image processing. Edge detection performs the locating sharp discontinuities in an image. This is the most common approach for detecting meaningful discontinuities in intensity values. The edge is a boundary between two regions with relatively distinct gray level properties. In edge detection, many operators are defined such as sobel, log, canny, prewitt. Edge detection example figure is given below.

Fig.11 Sobel Edge Detection

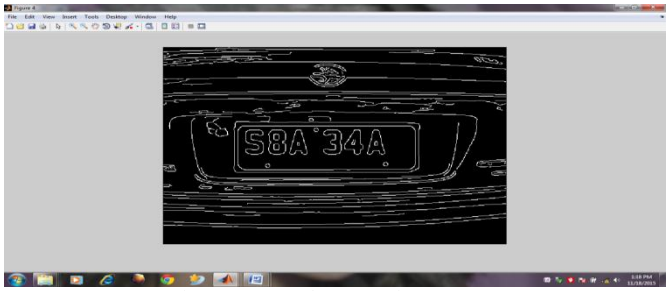


Fig.12 Canny Edge Detection

Fig.13 Prewitt Edge Detection

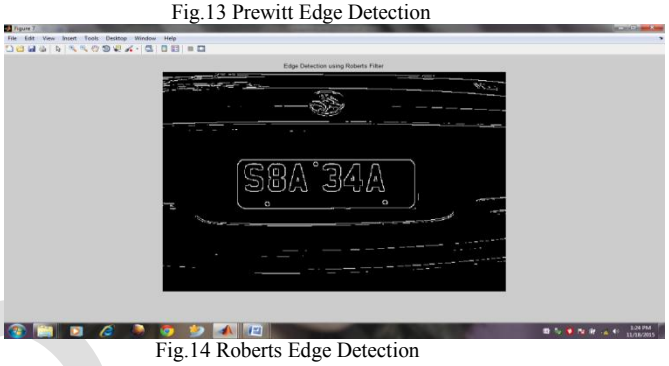


Fig.14 Roberts Edge Detection

Fig.15 Log Edge Detection

The Canny operator was designed to be an optimal edge detector. It takes as input a gray scale image, and produces as output an image showing the positions of tracked intensity discontinuities.

Brightness changes sharply. This change is measured by derivative in 1D. For biggest change derivative has max value (or) second derivative is zero. The detection of edge is most important as the success of higher level processing relies heavily on good edges. Gray level images comprise of an enormous data, usually much of which is extraneous. The general edge detection involves three steps: filtering, differentiation and detection. In the first stage, the image is allowed to pass through a filter to remove the noise involved. The differentiation stage highlights the points in the image where intensity changes are symbolic. In the detection stage, those points ,where the intensity changes are symbolic, are confined. Edges characterize object boundaries and are useful for segmentation (process of partitioning digital image into segments) identification of objects in a scene. The convolution matrix defines the logic of how the specific pixel is affected by adjoining pixels in the process of convolution.

The pixel represented by the cell *y* in the destination image is affected by the pixels $x_0, x_1, x_2, x_3, x_4, x_5, x_6, x_7$, according to the formula: $y= x_0m_0+ x_1m_1+ x_2m_2+ x_3m_3+ x_4m_4+ x_5m_5+ x_6m_6+ x_7m_7+ x_8m_8$, we have applied the Sobel Edge Detection to find the edges of the given image. The process is explained in the figure below

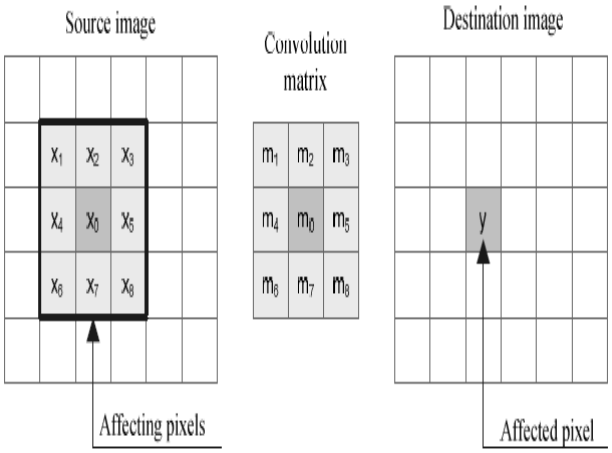


Fig.16 Convolution process for edge detection using sobel

$$G_x = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix}; G_y = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}$$

Fig. 17 : Convolution matrices of Sobel edge detector

1) Connected components

Connected components labeling first scans an image and bunches its pixels into components established on the basis of pixel connectivity, i.e. all pixels in a connected component share similar pixel intensity values and even are connected with each other in some way. Once all groups have been determined, labeling is done to each pixel with a gray level or a color (color labeling) according to the component it was accredited to. After the localization of the number plate of the vehicle involved, we need to nail the number plate into a standard form. The vehicular number plates maybe of Non-standard forms and may vary in their fonts.

D. Plate region extraction

Method 1:
The fourth step of the ALPR algorithm is the extraction of the number plate in an image. Find the row and column value of that image, then modify the image by using r/3:r and save the image in another variable. Assign the location and display the image. Find the row and column for modified image. Create one dummy image in the size of modified image row and column, and find the each and every pixel value. If the pixel value is greater than 150 means put the value 1 in dummy image else put 0 in dummy image, then apply median filter for that image. Find the region props of the image means it will calculate the centroid, boundary etc, then we have some condition. Based on that condition we apply the further procedure. Following shows the extracted number plate.
Equations:
b=a(R/3: R, 1: C);
a = Original Image, R= Row, C= column.
Find the area number using following equations
B=STATS. BoundingBox;
X_{min}=B (2);
X_{max}=B (2) +B (4);
Y_{min}=B (1);
Y_{max}=B (1) +B (3);
LP=b (X_{min}+25: X_{max}-20, Y_{min}+10: Y_{max}-10);

Method 2:
A number plate can be extracted by using image segmentation method. There are number of image segmentation methods which are available in various literatures. In most of the methods we use image binarization. Some authors use method suggested by Ostu for image binarization to convert color image to gray scale image. Some plate segmentation algorithms are based on color segmentation. Finds the License Plate Region in a RGB picture with the supplied safety spacing around the plate, and returns the coordinates of the discovered region. Selecting the license plates from the candidates in stat. The chosen area is the deepest region in the frame which has the following properties:
1. area> LP_MIN_AREA
2. LP_MIN_RATIO <= height/width <= LP_MAX_RATIO
3. area>= max(areas of the candidates)/3.5
The chosen area is the deepest region in the frame which has the following properties:
1. LP_MIN_AREA =20 X 134 = 2680
2. LP_MAX_RATIO =(H/W) =(160/240)= 0.67
3. LP_MIN_RATIO =(H/W) = (40/240) = 0.16

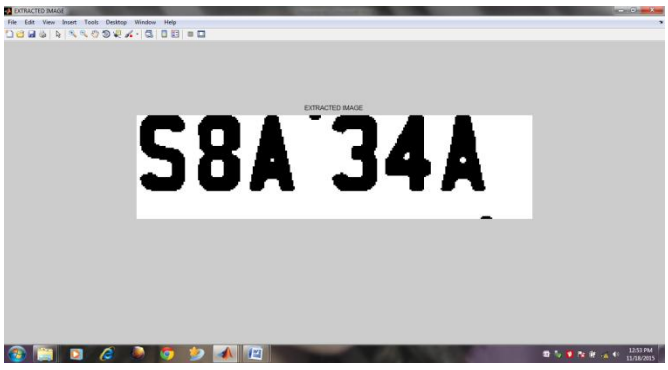


Fig.18 Extracted Image

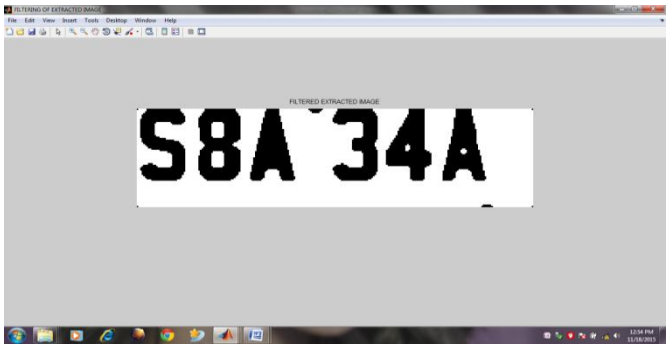


Fig.19 Filtered Extracted Image

E. Morphological operations

Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. The most basic morphological operations are dilation and erosion. Dilation performed by adding pixels to the boundaries of objects for all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1. Dilation is used for the purpose of increasing thickness of the number plate edges. So we can find the numbers easily. In erosion the value of the output pixel is the minimum value of all the pixels in the input pixel's neighborhood. In binary image, if any of the pixels is set to 0, the output pixel is set to 0.

IM2 = imopen(IM,SE) performs
morphological opening on the grayscale or binary image IM with the structuring element SE. The argument SE must be a single structuring element object, as opposed to an array of objects. The morphological open operation is an erosion followed by a dilation, using the same structuring element for both operations. The following figure shows the operation of imopen on image

Fig.20 Image after morphology operation imopen

IM2 = imclose(IM,SE) performs morphological
closing on the grayscale or binary image IM, returning the closed image, IM2. The structuring element, SE,must be a single structuring element object, as opposed to an array of objects. The morphological close operation is a dilation followed by an erosion, using the same structuring element for both operations. The following figure shows the operation of imclose on image

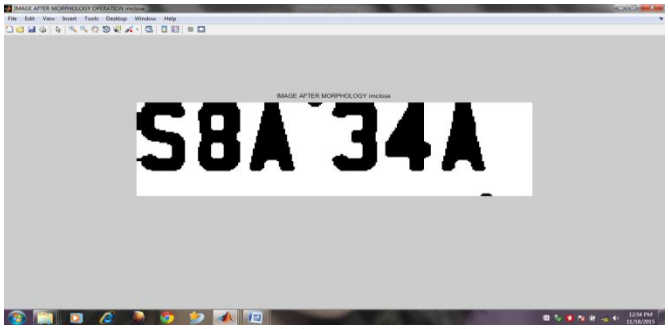


Fig.21 Image after morphology operation imclose

F. Character segmentation

The goal of this phase, given the dilation image, is to segment all the characters, without losing features of the characters. Segmentation is one of the most important processes in the automatic number plate recognition. If the segmentation fails, a character can be improperly divided into two pieces, or two characters can be improperly merged together. In order to recognize the vehicle number plate characters afterwards, each character must be divided respectively. The individual characters have to be distinguished (segmented) from each other. In Character Segmentation, the characters & digits of the plate are segmented and each is saved as different image. Matlab toolbox function provides a function called regionprops (). It measures a set of properties for each labeled region in the label matrix. The bounding box is used to measure the properties of the image region. In this step the o/p of extracted number plate is get using labelling components, and then separate each character and split the each and every character in the number plate image by using split. Also find the length of the number plate, then find the correlation and database if both the value is same means it will generate the value 0-9 and A - Z And finally convert the value to string and display it in edit box. Also store the character in some text file in this code. Following figure shows the process for segmented characters:

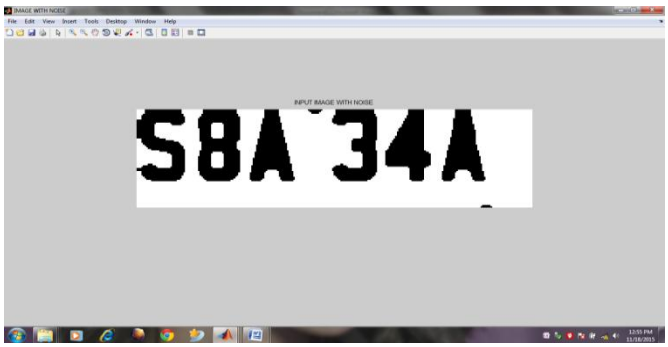


Fig.22 Image input with noise

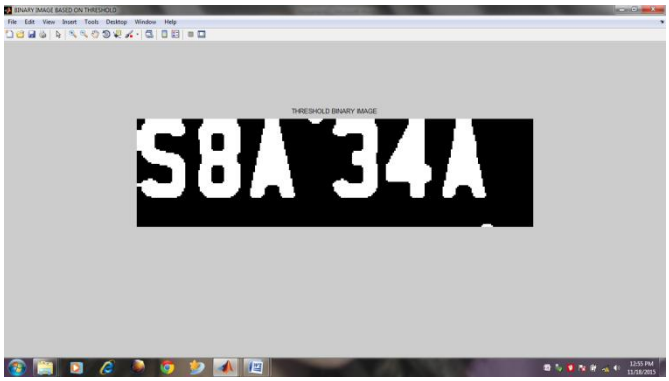


Fig.23 Threshold binary image

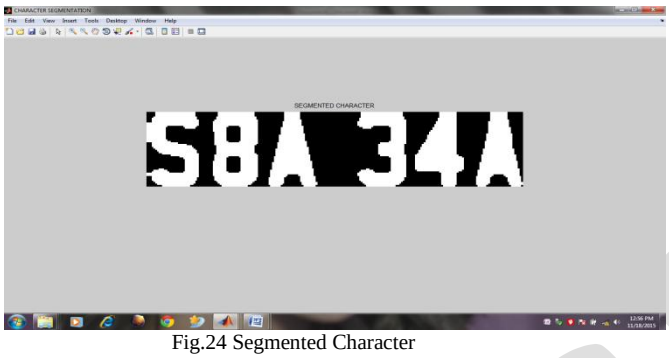
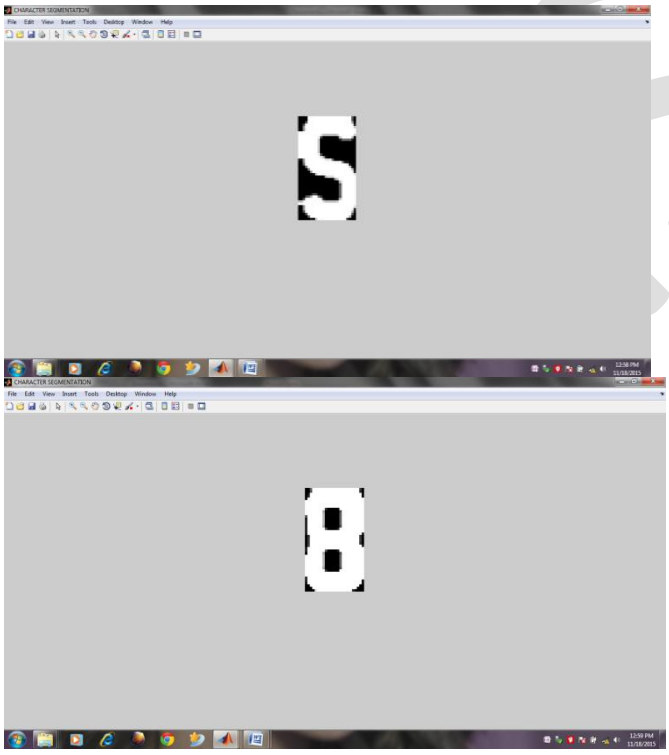


Fig.24 Segmented Character



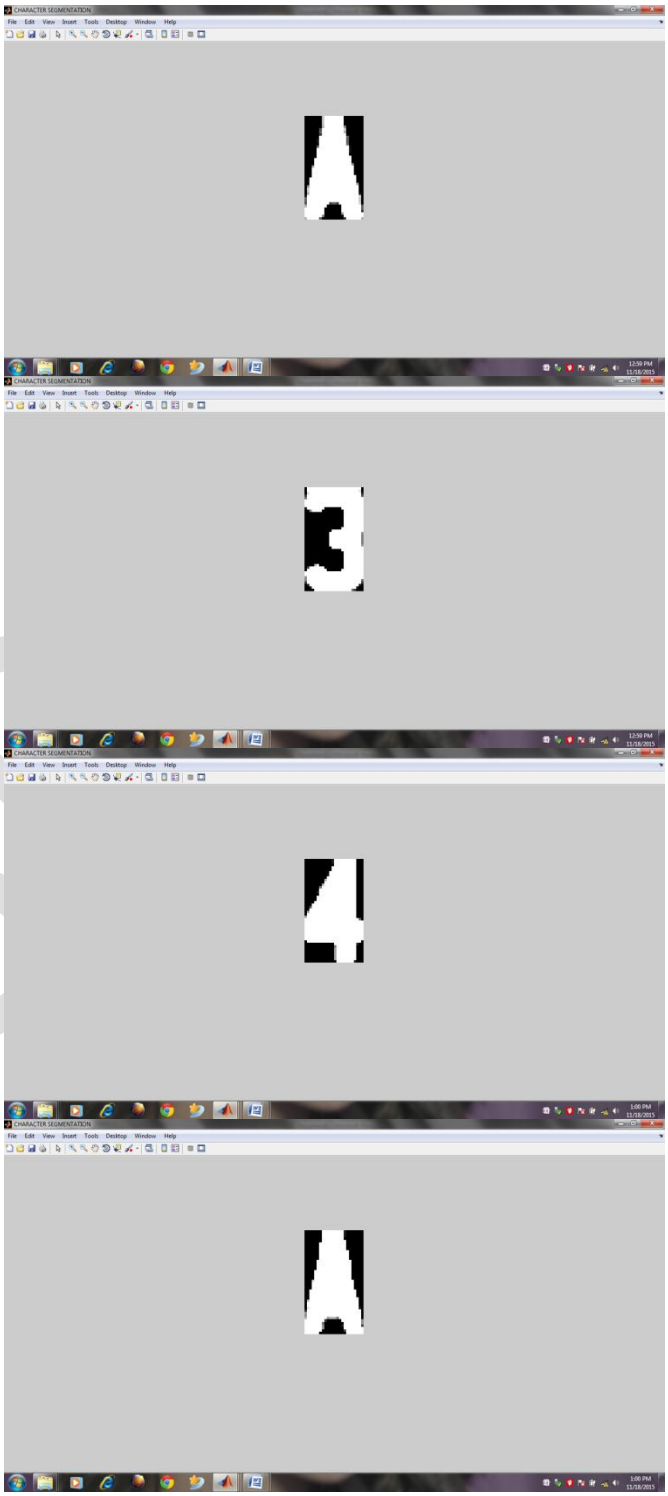


Fig.25 Segmented characters

G. Optical Character recognition

The goal of Optical Character Recognition (OCR) is to classify optical patterns (often contained in a digital image) corresponding to alphanumeric or other characters. The character has been extracted after the filtering. This character has been matched with the pre-defined characters. The pre-defined characters have the data like Alphabets A-Z, numeric character 0-9. This pre-defined data are in the form of the images. Using these images the template has been matched with the segmented characters of the number plate.

Template Matching:

Template Matching is one of the most common classification methods. In Template Matching, the features that the classification is based on are the individual pixels. An image is compared with predefined images, which are referred to as templates. The template are given below in figure 26

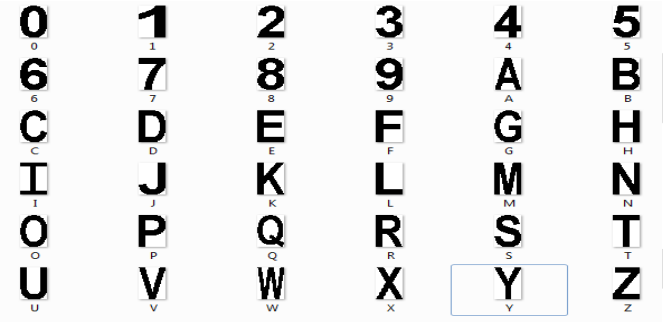


Fig. 26 Templates in the database

OCR is the mechanical or electronic translation of images of handwritten or typewritten text (usually captured by a scanner) into machine-editable text. The procedure consists of two important steps: training and recognition. The program is first trained with a set of sample images for each of the characters to extract the important features based on which the recognition operation would be performed. Our program is trained on a set of 10 characters with 10 samples of each. The OCR is now used to compare the each individual character against the complete alphanumeric database. The OCR basically uses correlation method to match individual character and then finally the number is identified and stored in string format in a variable. The string is then compared with the stored database for the vehicle authorization. Recognized number plate string is compare with authenticated database file. If both the value are same means it will display the 'authorized' else it will display the 'unauthorized'.

H. Number Extraction

The character segmentation algorithm is used to segment the character. Due to this character segmentation process noise is added and that noise is removed using the filter. The noise removed character is matched with template using template matching algorithm and finally the character is extracted in notepad.

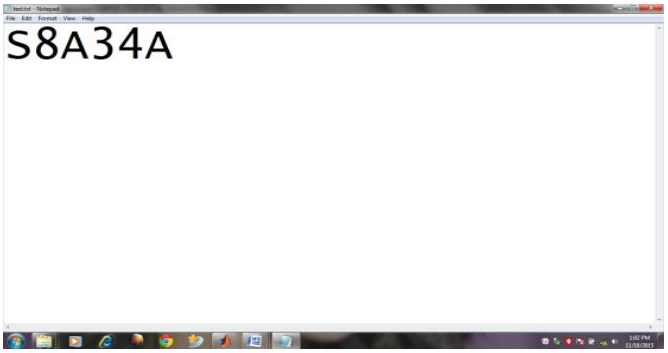
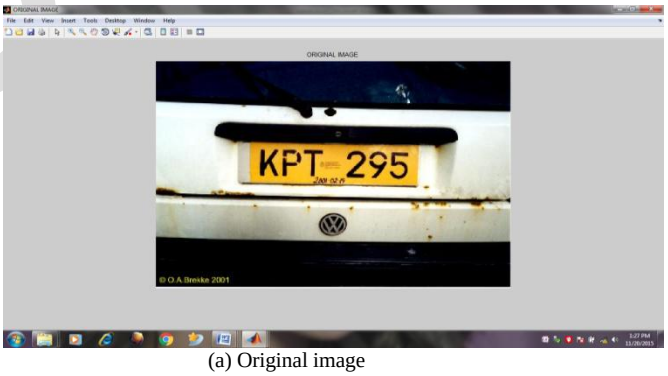


Fig.27 Converted to text

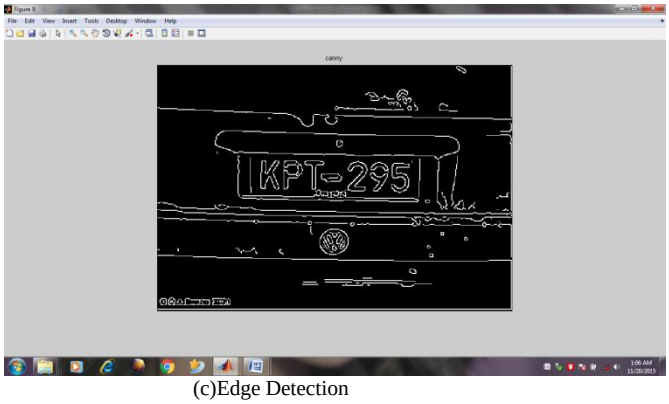
IV. RESULTS AND ANALYSIS

Experiments have been performed to test the proposed Car Number Plate Recognition system. Here, various images are tested using by optical character recognition. Experiments show that the algorithm has good performance on number plate extraction, and character segmentation work. The results produced from the implementation of the algorithm are presented in this section. In figure 27, all the figures (a-f) are denoted to extract the numbers from the car number plate image.



(a) Original image

(b)GrayScale Image



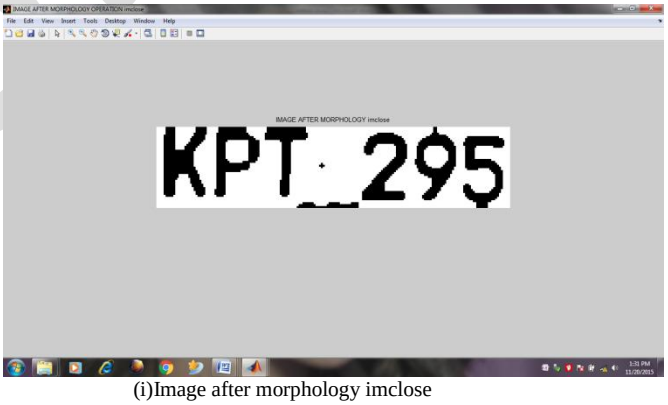
(c)Edge Detection

(g)Filtered Extracted Image

(d) Binary image

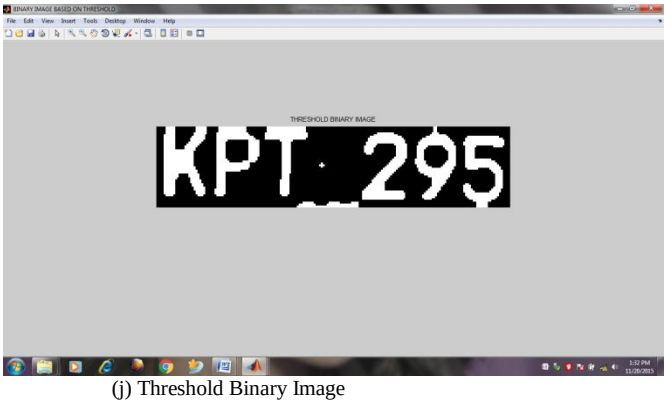
(h)Image after morphology imopen

(e) Filtered Image

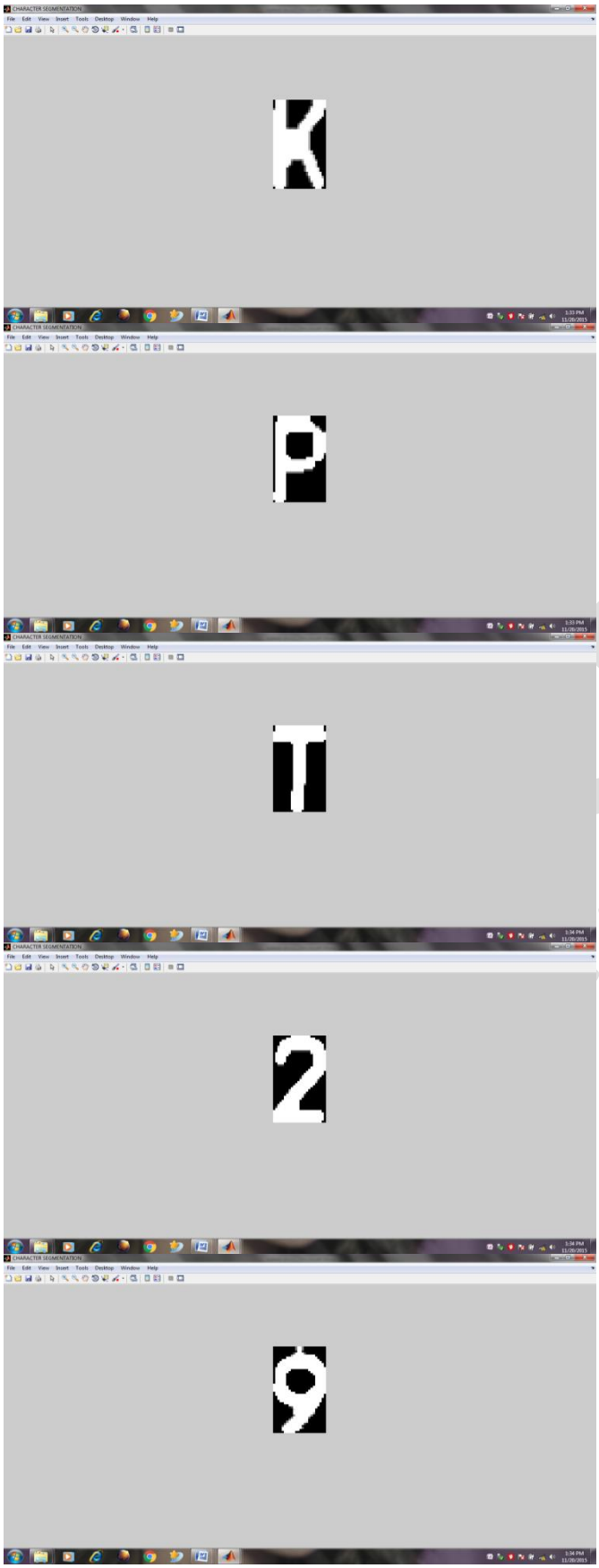


(i)Image after morphology imclose

(f) Extracted Image



(j) Threshold Binary Image



(k) image converted to text and stored in notepad

Fig.28(a-k)

1)Analysis

In this proposed system, edge detection operators are used to detect the edges. They are sobel, log, prewitt and canny. On comparing these operators canny edge detector is considered as the best one. To conclude that canny is given good result of this analysis is done as follows:

In TableIII (a), (b),(c) considered by four different edge detection operators. Finally the best result is given by canny edge operator.

2) Quality Measurement

Mean Square Error (MSE), MSE is computed by averaging the squared intensity of the original (input) image and the resultant (output) image pixels. Peak Signal-to-Noise Ratio (PSNR) is a mathematical measure of image quality based on the pixel difference between two images. Here, these two values are find it. For the purpose of find the quality of edges. The values of MSE and PSNR are calculated in TABLE IV

3) Comparison of various images

Testing is done on the various images to this system. Check the correct number plate from the result. If the result is failed the column is given as Result is failure. In Table V number of car images were tested for successful result at the same time the failure case also detected. In this work the image no 1 was failure case and the reason is the image has been not cleared.

TABLE III(a)

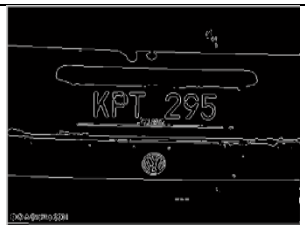
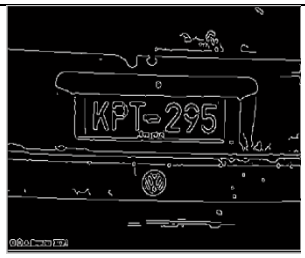
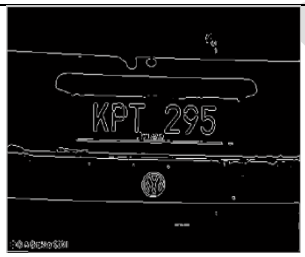
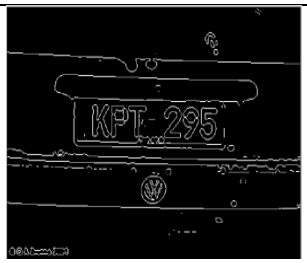
Input Image				
Sobel Edge				
Canny Edge				
Prewitt Edge				
Roberts Edge				
Log Edge				

TABLE III (b)

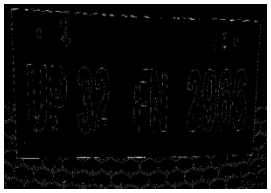
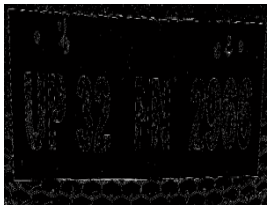
Input Image				
Sobel Edge				
Canny Edge				
Prewitt Edge				
Roberts Edge				
Log Edge				

TABLE III (c)

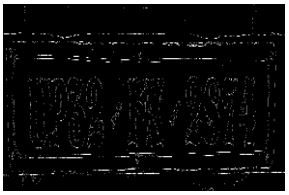
Input Image				
Sobel Edge				
Canny Edge				
Prewitt Edge				
Roberts Edge				
Log Edge				

Table IV
Quality Measurement with MSE and PSNR

Input Image	Sobel Edge		Canny Edge		Prewitt Edge		Roberts Edge		Log Edge	
	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR
Plate 1	0.213	6.722	0.229	6.393	0.212	6.722	0.212	6.727	0.208	6.812
Plate 2	0.358	4.460	0.360	4.434	0.358	4.460	0.363	4.398	0.341	4.672
Plate 3	0.722	1.417	0.715	1.457	0.722	1.416	0.720	1.429	0.702	1.538
Plate 4	0.413	3.837	0.405	3.925	0.413	3.838	0.414	3.834	0.401	3.972
Plate 5	0.650	1.872	0.644	1.914	0.650	1.872	0.650	1.868	0.640	1.941
Plate 6	0.637	1.955	0.632	1.991	0.638	1.955	0.639	1.947	0.630	2.010
Plate 7	0.354	4.512	0.360	4.442	0.354	4.513	0.350	4.557	0.335	4.751
Plate 8	0.277	5.574	0.297	5.278	0.277	5.574	0.277	5.581	0.280	5.523
Plate 9	0.573	2.422	0.567	2.467	0.573	2.421	0.564	2.487	0.526	2.788
Plate 10	0.362	4.413	0.372	4.290	0.362	4.414	0.362	4.409	0.361	4.312
Plate 11	0.703	1.528	0.704	1.523	0.703	1.528	0.702	1.537	0.696	1.574
Plate 12	0.460	3.372	0.442	3.542	0.460	3.376	0.449	3.479	0.404	3.938

BAR CHART FOR MSE

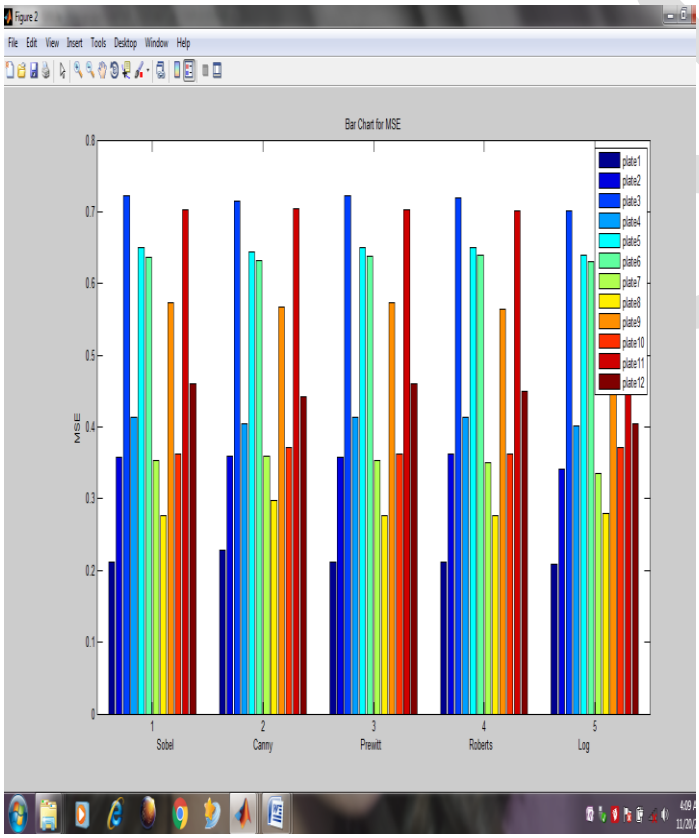


Fig29. Bar Chart for MSE

BAR CHART FOR PSNR

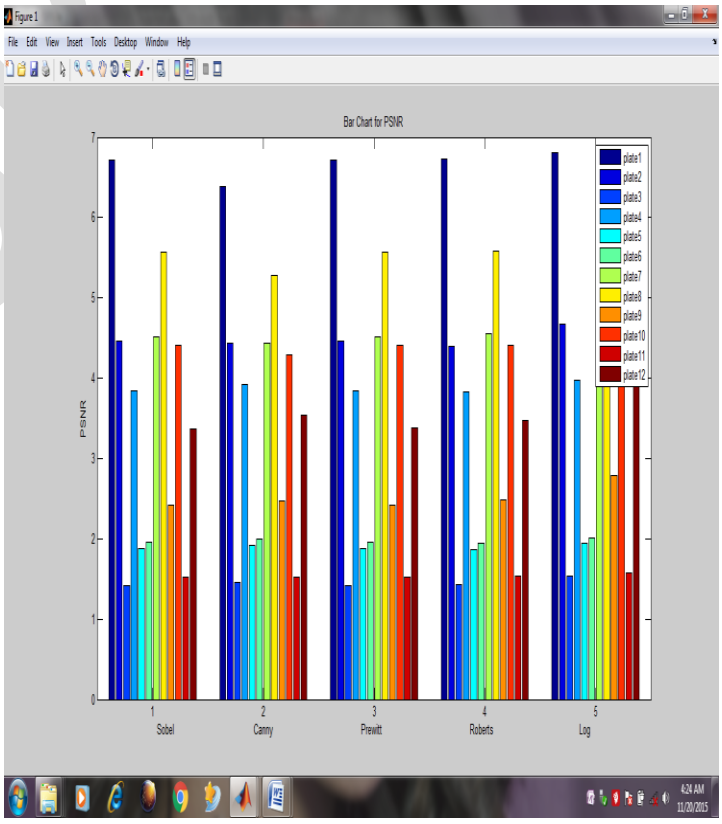


Fig30. Bar Chart for MSE

Table V
TESTED IMAGES

Input Image	Number Read by our system	Result
	HH01GA4570	**Failure**
	GFCP51	**Successful**
	874VA	**Successful**
	UP32D8765	**Successful**
	4NYN4HE	**Successful**
	FBR444	**Successful**

V. CONCLUSION

We have implemented number plate recognition. The number plate region from the image which consists of vehicle number & then character segmentation and recognition is being successfully done by our algorithm.We have applied our algorithm on many images and found that it successfully recognizes. The project was designed keeping in mind the automation of the number plate detection system for security reason that could replace the current system of manual entry. This project was a success in recording the number plate of a vehicle inspite of the fact that it has got its certain own limitation of image processing and other hardware requirements. From this project we learn about image processing and OCR (Optical Character Reader) and how the automatic vehicle identification system using vehicle license plate is presented. The system use series of image processing techniques for identifying the vehicle from the database stored in the PC. The system gets implemented in Matlab and its performance is tested on real images. The simulation results shows that the system robustly detect and recognize the vehicle using license plate against different lightening conditions and can be implemented on the entrance of a highly restricted areas. This paper presents a recognition method in which the vehicle plate image is obtained by the digital cameras and the image is processed to get the number plate information. A rear image of a vehicle is captured and processed using various algorithms. Further we are planning to study about the characteristics involved with the automatic number plate system for better performance.

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