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An Efficient Approach for Automatic Number Plate Recognition System under Image Processing

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Abstract- Automatic Number Plate Recognition (ANPR) system is an image processing technology that identifies the vehicles by tracking their number plate without direct human intervention and an application of computer vision. ANPR is an important method used in Intelligent Transportation System (ITS). The four phases of the ANPR system: Image acquisition and pre-processing, number plate extraction, character segmentation and character recognition are discussed in this paper. Number Plate Extraction is most crucial step in the ANPR system which affects the overall accuracy and efficiency of whole ANPR system. The quality of acquired vehicle image is a major factor in the success of ANPR. In this paper we have proposed an efficient approach for ANPR in which the input vehicle image is firstly pre-processed using iterative bilateral filter and adaptive histogram equalization and number plate is extracted from pre-processed vehicle image using morphological operations, image subtraction, thresholding, sobel edge detection and boundary box analysis.
We compared the result of our proposed approach with existing method of ANPR.

Keywords - Automatic number plate recognition, histogram equalization, adaptive histogram equalization, iterative bilateral filter, median filter, number plate extraction, morphological operations, image subtraction, thresholding, sobel edge detection, connected component analysis, boundary box analysis, character segmentation, character normalization, template matching, character recognition.

I. INTRODUCTION

Automatic Number Plate Recognition (ANPR) system is a technology solution that takes photographs of vehicles and by extracting the number plate from whole image it segments the characters present on the number plate and then by using the template matching scheme, it translates the license number of pixel value into numerical or string. The main aim of the system is to properly identify and locate the vehicle number plate information and replace the manual systems with an automated system. ANPR system is an image processing technology that is used to identify the vehicles by tracking their number plate without direct human intervention [6] [7]. ANPR is the extraction of vehicle number plate information from an image or a sequence of images. The quality of the acquired images is a major factor in the success of the ANPR. ANPR as a real-life application has to quickly and successfully process number plates under different environmental conditions, such day or night time. It should also be generalized to process license plates from different nations or states [2].

Due the increasing number of stolen vehicles from year to year, researchers had introduced various methods to detect the characters and numbers in license plate of various types of vehicles. ANPR system is important method used in Intelligent Transportation System (ITS). Vehicles play important role in transportation. Due to population growth and human needs, the use of vehicles has been increasing day by day. Therefore the control of vehicles is becoming a big problem. ANPR system is one of the methods used for the effective control of these vehicles [6] [17]. There are number of applications of ANPR such as automatic toll collection at toll plaza, traffic monitoring, automatic ticketing of vehicles at parking area, tracking vehicles during signal violation, border control, stolen car detection, access control in building and parking areas etc [2] [9] [12].

ANPR is also known as Number Plate Tracking (NPT), Vehicle Number Plate Recognition (VNPR), Car Plate Recognition (CPR), Automatic License Plate Reader (ALPR), License Plate Recognition (LPR), Vehicle Number Recognition (VNR) etc [2] [13]. ANPR typically includes four steps, image acquisition and pre-processing, number plate detection and extraction, character segmentation and character recognition. The basic model of ANPR system consists of four phases shown in fig. 1 [2] as follow:-

a. Image Acquisition and Pre-processing
b. Number Plate Extraction (NPE)
c. Character Segmentation (CS)
d. Character Recognition (CR)

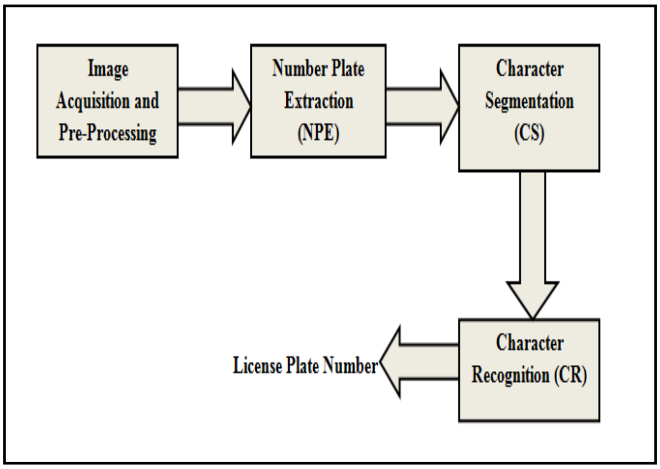

Figure.1: The Basic Working of ANPR System

Image acquisition means how to acquire the input image. In ANPR system digital camera of high resolution is used to acquire the input image. Images are taken in different background and illumination conditions [19]. The basic purpose of pre-processing is to enhance the processing speed, to remove noise from input image, to improve the contrast of the image so that to increase and improve the visibility and quality of input image [1]. The Number Plate Extraction (NPE) is the second and most important phase of ANPR. The captured input image has number plate covered by vehicle body, so by this step only number plate area is detected and extracted from whole body of vehicle. The number plate extraction phase influence the accuracy of ANPR system because all further steps depend on the accurate extraction of number plate area. The input to this stage is vehicle image and output is a portion of image containing the exact license plate [2]. The extraction of Indian number plate is difficult as compared to the foreign number plate because in India there is no standard followed for the aspect ratio (length/width ratio) of plate. This factor makes the detection and extraction of number plate very difficult [20]. Character Segmentation (CS) acts as bridge between the number plate extraction and character recognition phase. In this phase the characters on number plate area are segmented one by one. There are many factors such as image noise, space mark, plate frame, plate rotation and illumination variance etc. that make the character segmentation task difficult. Character recognition (CR) is the last phase of ANPR system. The inputs to this phase are segmented characters and output of this phase is license plate number. In this phase the segmented characters are recognized. Character recognition (CR) in ANPR system has some difficulties. Sometimes the segmented or extracted characters do not have the same size. The better way to overcome this problem is to resize the characters into one size before recognition starts.

This paper is organized in V sections. Section II explains literature survey, Section III explain proposed approach for automatic number plate recognition system. Experimental result is shown in section IV. Conclusions and future work is given in Section V.

II. LITERATURE SURVEY

Christos-Nikolaos E. Anagnostopoulos [1] presented a brief tutorial on LPR. LPR typically includes three steps: - license plate detection, character segmentation and optical character recognition. This paper provides a brief reference of relevant literature, according to their major methodology in the three typical steps of license plate recognition. Shan Du [2] presented a comprehensive survey on existing ALPR techniques by categorizing them according to the features used in each stage and compare them in terms of pros, cons, recognition accuracy, and processing speed. Sahil Shaikh [3] described the method proposed for number plate recognition. For plate localization, several traditional images processing techniques are used. Techniques such as image enhancement, edge detection, filtering and component analysis each plays a role in the extraction process. For character segmentation, connected components are extracted as individual number plate characters. Template Matching is used for Character Recognition. Norizam Sulaiman [4] proposed the development of automatic vehicle plate detection system. In this method after pre-processing the candidate plate is detected by means of feature extraction method, character segmentation is done by boundary box and character recognition is done by template matching.

Reza Azad [5] proposed a fast and real time method which has an appropriate application to find tilt and poor quality plates. In the proposed method, at the beginning, the image is converted into binary mode using adaptive threshold. Ronak P Patel [6] proposed new algorithm for recognition number plate using Morphological operation, Thresholding operation, Edge detection, Bounding box analysis for number plate extraction, character separation using Segmentation and character recognition using Template method and Feature extraction. Najeem Owamoyo [7] presented Automatic Number Plate extraction, character segmentation and recognition for Nigerian vehicles.

Number plate extraction is done using Sobel filter, morphological operations and connected component analysis. Character segmentation is done by using connected component and vertical projection analysis. Sourav Roy [8] presented a system to localization of number plate mainly for the vehicles in West Bengal (India) and segmented the numbers as to identify each number separately. This approach is based on simple and efficient morphological operation and sobel edge detection method. After reducing noise from the input image enhancement of contrast of the binarized image is done using histogram equalization. Divya Gilly [9] presented an efficient method for LPR. LPR system mainly consists of three phases 1) plate detection 2) character segmentation 3) character recognition. This method utilizes a template matching technique. The methodology is suitable for both Indian license plates and foreign license plates. S. Hamidreza Kasaei [18] presented a real time and robust method of license plate detection and recognition based on the morphology and template matching.

This paper represent an efficient approach for ANPR in which the input vehicle image is firstly pre-processed using iterative bilateral filter and adaptive histogram equalization and number plate is extracted from pre-processed vehicle image using morphological operations, image subtraction, thresholding, sobel edge detection and boundary box analysis. After the extraction of plate area, the extracted plate is enhanced by using morphological operations to improve the quality of extracted plate so that the segmentation phase gives more successful output. The character segmentation is done by connected component analysis and boundary box analysis and finally the character recognition is done by template matching using correlation.

III. PROPOSED APPROACH FOR ANPR

The proposed approach for automatic number plate recognition system is represented in this section. The existing ANPR method works well for dark and light images but it does not work well for low contrast, blurred and noisy images. But the proposed approach for ANPR works well for all these categories of images. The flowchart of proposed approach for ANPR is shown in fig.2 consists of following main steps:

a. Image Acquisition
b. RGB to Grayscale conversion
c. Noise removal by Iterative Bilateral Filtering
d. Contrast enhancement by using Adaptive Histogram Equalization (AHE)
e. Morphological Opening and Image Subtraction Operations
f. Image Binarization
g. Edge detection by Sobel operator
h. Candidate Plate Area Detection by Morphological Opening and Closing Operations

i. Actual Number Plate Area Extraction
j. Enhancement of Extracted Plate Region using Morphological Operations
k. Character Segmentation (CS)
l. Character Recognition (CR)

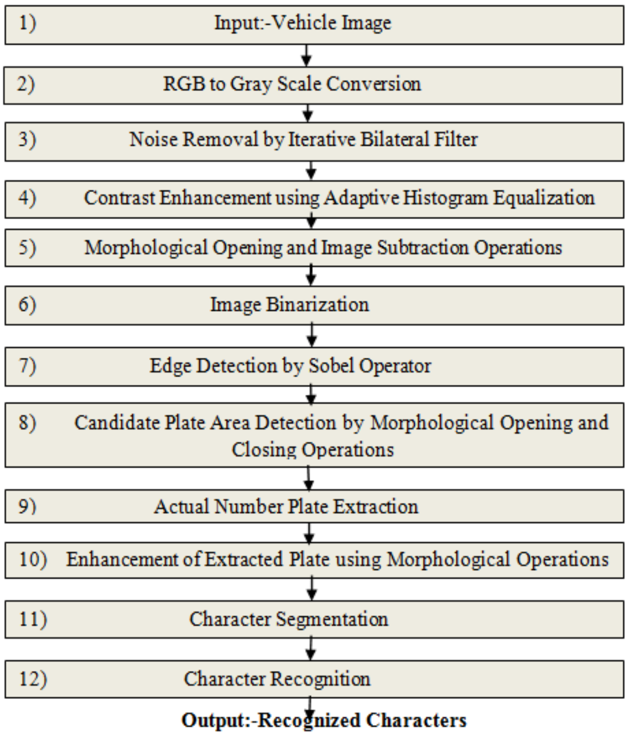

Figure.2: Flowchart of Proposed Approach for ANPR

A. *Image Acquisition:*

The first step of ANPR is image acquisition which means to acquire the input image of vehicle. Image is acquired by digital camera. Images are taken in different background and illumination conditions and at various distances from the camera. Due to poor illumination conditions the acquired image can be of low contrast. Weather conditions (fog, snow, rain) are responsible for introducing "noise" during camera capturing. Different types of images can be acquired during camera capturing that is Light Images, Dark Images, Low Contrast Images, Blurred Images and Noisy Images. Fig. 3 shows the low contrast vehicle image.

Figure.3: Input Vehicle Image

B. *Pre-Processing:*

The basic aim of pre-processing is to improve the contrast of the input image, to reduce the noise in the image, hence to enhance the processing speed, to increase and improve the visibility and quality of input image. In the proposed approach for ANPR, in pre-processing step firstly the RGB image is converted into gray level image and then the noise from the gray scale image is removed by using iterative bilateral filtering and finally the filtered image is enhanced by applying Adaptive Histogram Equalization (AHE) technique as follow:

a. ***RGB to Gray Scale Conversion:*** The captured input image is RGB format. The first step of pre-processing is to convert RGB image into gray-scale image. Fig. 4 shows the gray scale image.

Figure.4: Gray Scale Image

b. ***Noise Removal by Iterative Bilateral Filter:*** In the proposed method iterative bilateral filter is used for noise removal. Iterative bilateral filter is non-linear filter. It provides the mechanism for noise reduction while preserving edges more effectively than median filter. The iterative bilateral filter results into less blurring effect while smoothing an image than the median filter. The image reconstructed with iterative filter has high PSNR value as compared to the image reconstructed with median filter. Hence the image filtered by iterative bilateral filter has better quality than the image reconstructed with median filter. The result of applying iterative bilateral filter on gray scale image is shown in Fig.5.

Figure.5: Result of applying iterative bilateral filter on gray scale image

c. ***Contrast Enhancement using Adaptive Histogram Equalization:*** Contrast is defined as difference between lowest and highest intensity level. In the proposed approach the contrast is enhanced by Adaptive histogram equalization (AHE). AHE shows better contrast than histogram equalization (HE). This is because in AHE the test functions according to which we enhance the contrast of input vehicle image depend upon gray levels, local properties and spatial co-ordinates of pixels while in case of HE the test function value depend only on the gray levels of pixel of image. The image reconstructed with adaptive histogram equalization (AHE) has high PSNR value as compared to the image reconstructed with histogram equalization (HE). Hence the image enhanced by adaptive histogram equalization (AHE) has better quality than the image enhanced with histogram equalization (HE). Fig.6 shows contrast enhancement by adaptive histogram equalization.

Figure.6: Contrast Enhancement using Adaptive Histogram Equalization

C. Morphological Opening and Image Subtraction Operations:

In the proposed approach the opening operation firstly the disc shaped structuring element (SE) is created and then the opening operation is performed on the adaptive contrast enhanced gray scale image by using disc shaped structuring element (SE) and then in the image subtraction operation, the morphological opened image is subtracted from adaptive contrast enhanced gray scale image so that the number plate area get highlighted. Fig. 7 shows the result of opening operation and fig. 8 shows the result of image subtraction between the contrast enhanced gray scale image and opened image.

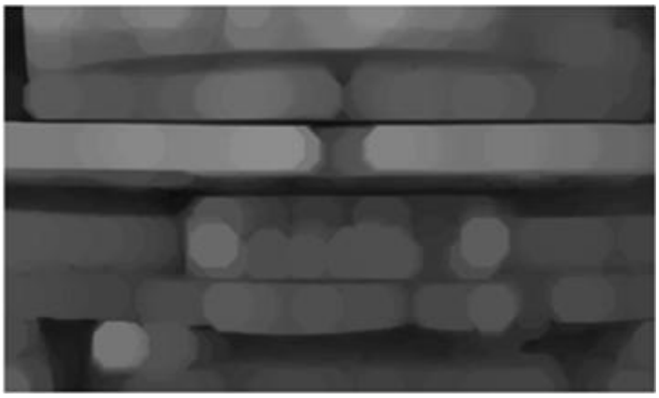

Figure.7: Opening effect using disk

Figure.8: Image Subtraction

D. Image Binarization:

In image binarization step the image is converted to black and white format. The purpose of applying color conversion is to reduce the number of range of the color scale from (0-255) to (0-1). In the proposed approach the subtracted gray scale image is converted into binary image in this step. Firstly the global threshold level is calculated by Otsu's method [9] and then according to the calculated threshold the subtracted gray scale image is converted into black and white image. Fig. 9 shows binarized image.

Figure.9: Binarized Image

E. Edge Detection by Sobel Operator:

Edges are detected by sobel operator. Sobel operator consists of two types of masks. One is horizontal sobel mask and vertical sobel mask. The result of applying sobel operator to binarized image is shown in Fig.10 as follow:-

Figure.10: Edge Detection by Sobel operator

F. Candidate Plate Area detection by Morphological Opening and Closing Operations:

In the proposed ANPR approach for the detection of candidate plate area, firstly dilation operation is applied on sobel edge detected image and then the holes are filled in this dilated image using MATLAB *imfill* function. After this the unwanted portion of image is removed by using opening operation and finally the candidate plate area is detected by using erosion operation. The result of applying dilation operation and filling holes is shown in fig. 11 and 12 respectively. Then morphological opening and erode operations are used for exact detection of candidate plate area and its result in shown in Fig. 13.

Figure.11: Morphological Dilation Operation

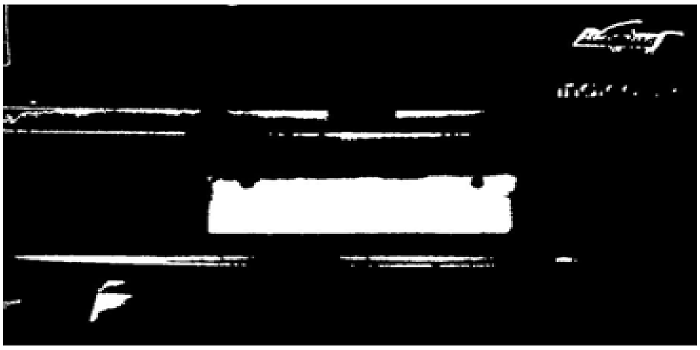

Figure.12: Image after filling holes

Figure.13: Number Plate Area Detection

G. Actual Number Plate Area Extraction:

After the detection of number plate area that area is extracted from the image. The efficiency of number plate extraction depends on accurate detection of number plate area. In the proposed approach, after the detection of candidate plate area, the row and column indices of plate area plate area are found by Boundary Box Analysis (BBA) and then that portion is extracted from the image. Fig. 14 shows the actual number plate extracted area.

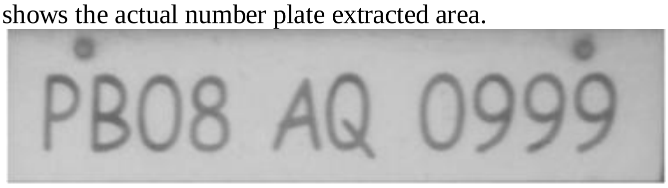

Figure.14: Extracted True Number Plate

H. Extracted Plate Region Enhancement:

The extracted number plate may consist of various noise, unwanted holes, frames, bolts etc. So enhancement of plate region is done. In the proposed approach the enhancement of extracted plate region is done by using various morphological operations. Fig.15 shows the result of plate region enhancement by morphological dilation, erosion, opening and closing operation on extracted plate region.

Figure.15: Enhanced Plate Region

I. Character Segmentation:

Character Segmentation (CS) step acts as bridge between the number plate extraction and character recognition phase. In this phase the characters on number plate area are segmented. There are many factors such as image noise, space mark, plate frame, plate rotation and illumination variance etc. that make the character segmentation task difficult. In the proposed approach the character segmentation is done by Connected Component Analysis (CCA) and Boundary Box Analysis (BBA). Firstly labels are assigned to connected components and the labeled characters are extracted using boundary box analysis. Fig.16 shows the result of character segmentation.

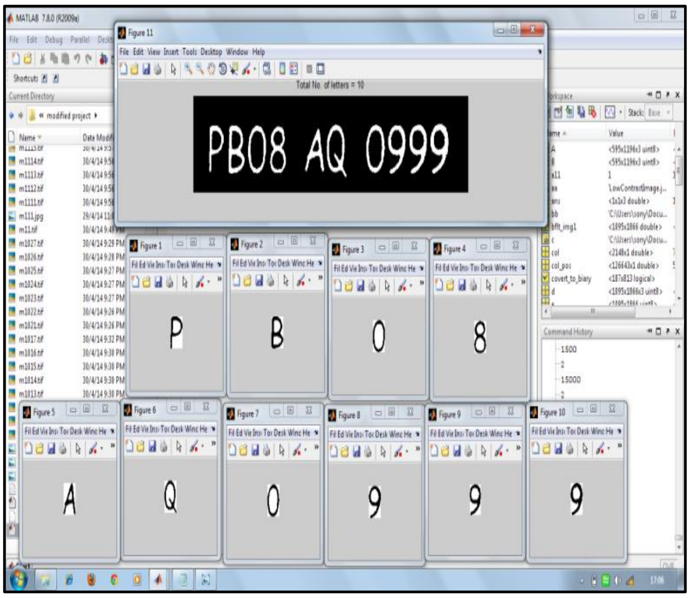

Figure.16: Output of Character Segmentation

J. Character Recognition:

Character recognition (CR) is the last phase of ANPR system. The inputs to this phase are segmented characters and output of this phase is license plate number. Difficulties are faced during character recognition. The character recognition is done by Template Matching using Correlation. In the proposed approach for ANPR, in the character recognition step firstly make template by taking 42 X 24 pixel A to Z alphabet and 0 to 9 number images. Read all image and store them in database and this result into 36 character templates. After this step character normalization is done. In character normalization, all the segmented characters are resized to template size 42 X 24. The main benefit of character normalization is that sometimes the segmented characters do not have the same size. The better way to overcome this problem is to resize the characters into one size before actual recognition starts. In last the segmented characters are matched with template characters using correlation. The similarity between the template characters and segmented characters is measured and the template that is most similar to the character is recognized as target. The value of correlation is calculated by comparing the normalized segmented character image with each template character image and selecting the most relevant image and writes that character into text file. Fig.17 shows the result of character recognition.

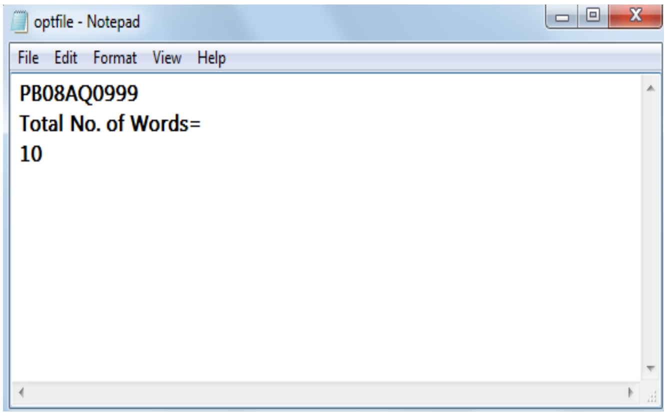

Figure.17: Output of character recognition

The existing ANPR method does not work well for Low Contrast, Blurred and Noisy images. But the proposed ANPR approach works well for Low Contrast, Blurred and Noisy images as well as for Dark and Light images. For example the input image as shown in fig.3 is of low contrast. When we applied the existing ANPR algorithm on this low contrast image, the extracted plate is not actual number plate area. As a result of this wrong extraction of number plate area, the character segmentation and character recognition are not successful in this case because these two phases are also depends on successful extraction of number plate area. But when we applied the proposed approach for ANPR on this low contrast image, it properly extracts the actual plate area. After the extraction of plate area, the extracted plate is enhanced by using morphological operations to enhance the quality of extracted plate so that the segmentation gives successful output. The character segmentation and character recognition is also successful in this case.

IV. EXPERIMENT RESULTS

This proposed approach for automatic number plate recognition system works well for low contrast, noisy and blurred as well as dark and light/bright input images. Total 90 vehicle's images are tested. Images are taken in different illumination conditions, at different distances relative to camera and are of different colors and different sizes images. The proposed approach is tested on various real time images of different image categories as using various performance metrics namely Peak Signal to Noise Ratio (PSNR) and Success Rate (%). In the proposed approach the success rate (%) in each phase of ANPR is higher and PSNR is also higher than that of existing ANPR method. The result of proposed approach for number plate extraction is shown in TABLE 1-5. This method is implemented in MATLAB 7.8.0.

A. Peak Signal to Noise Ratio (PSNR) :

The peak signal to noise ratio (PSNR) is used as a quality measurement between original and reconstructed image. Higher the value of PSNR, better the quality of the reconstructed image. An improvement in the PSNR magnitude will increase the visual appearance of the image. The PSNR value is calculated in **(dB)** at each step of existing and proposed ANPR method as shown in table 1-4 for each category of image as follow:

Table 1:- PSNR for different Images using Median Filter and Iterative Bilateral Filter Technique

Filtering Method	PSNR				
	Low Contrast Image (Image1)	Noisy Image (Image2)	Blurred Image (Image3)	Dark Image (Image4)	Light Image (Image5)
Median Filtering (Existing Method)	36.676	30.437	36.773	33.333	30.322
Iterative Bilateral Filtering (Proposed Method)	37.608	33.006	37.244	34.179	32.181

Table-2:- PSNR for different of Images using Histogram Equalization and Adaptive Histogram Equalization Technique

Enhancement Method	PSNR				
	Low Contrast Image (Image1)	Noisy Image (Image2)	Blurred Image (Image3)	Dark Image (Image4)	Light Image (Image5)
Histogram Equalization (HE) (Existing Method)	20.990	15.755	16.445	16.480	25.363
Adaptive Histogram Equalization (AHE) (Proposed Method)	26.355	24.936	22.764	23.745	25.976

Table 3:- PSNR for Morphological Opening Operation using Median Filter and Histogram Equalization (HE) Technique, Iterative Bilateral Filter and Adaptive Histogram Equalization (AHE) Technique

Number Plate Extraction Step	Method	PSNR				
		Low Contrast Image (Image1)	Noisy Image (Image2)	Blurred Image (Image3)	Dark Image (Image4)	Light Image (Image5)
Morphological Opening	Existing Method	21.553	18.816	19.901	18.906	15.693
	Proposed Method	22.772	29.907	21.820	22.656	16.050

Table 4:- PSNR for Candidate Plate Area Detection Operation using Median Filter and Histogram Equalization (HE) Technique, Iterative Bilateral Filter and Adaptive Histogram Equalization (AHE) Technique

Number Plate Extraction Step	Method	PSNR				
		Low Contrast Image (Image1)	Noisy Image (Image2)	Blurred Image (Image3)	Dark Image (Image4)	Light Image (Image5)
Candidate Plate Area Detection	Existing Method	13.218	17.944	15.452	17.594	12.858
	Proposed Method	13.748	18.247	15.657	17.806	12.995

B. *Success Rate (%):*

The success rate (%) is calculated for 3 different phases of ANPR. The success rate for number plate extraction phase is equal to the ratio of successfully extracted plates and total no. of input vehicle images. The success rate for character segmentation phase is equal to the ratio of successfully segmented plates and total no. of input vehicle images. The success rate for character recognition phase is equal to the ratio of successfully recognized plates and total no. of input vehicle images. If the ANPR approach gives higher value of success rate (%) it means that approach has better result as compared to ANPR approach that has low value of success rate. The success rate (%) is calculated for each phase of ANPR using existing and proposed approach as shown in table 5. The success rate (%) is higher in case of our proposed method as compared to existing method of ANPR.

Table 5:- Success Rate (%) for Different Stages of ANPR using Existing and Proposed Method

Stages of ANPR	Algorithm	Total No. of Input Images	Success	Failure	Success Rate (%)
Number Plate Extraction	Existing	90	85	5	94.44%
	Proposed	90	88	2	97.78%
Character Segmentation	Existing	90	83	7	92.22%
	Proposed	90	88	2	97.78%
Character Recognition	Existing	90	82	9	91.11%
	Proposed	90	87	3	96.66%

V. CONCLUSION & FUTURE WORK

In Automatic Number Plate Recognition Number Plate Extraction is most crucial step, the overall accuracy and processing speed of whole system as character segmentation and character recognition phases are also depend on extracted plate area that is the output of number plate extraction phase. In this paper we observed that our proposed ANPR approach works well for Low Contrast, Blurred and Noisy images as well as for Dark and Light images. Our proposed approach gives better result than the existing approach when compared using two performance metrics that are PSNR and Success Rate (%). Our approach gives higher value of PSNR and also high success rate (%) as compared to the existing ANPR method.

The future research of ANPR should concentrate on high definition plate image processing, multi-style plate recognition, and multi-plates processing at a time, video-based ANPR using temporal information and recognition of ambiguous characters and so on. The Future research can be concentrate on improving the recognition rate on ambiguous characters such as (O-0), (I-1), (A-4), (C-G) and broken characters.

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