*International Journal on Recent and Innovation Trends in Computing and Communication*
*ISSN: 2321-8169 Volume: 11 Issue: 10*
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

# An Algorithm for Vehicle Image Enhancement using Modified Fire Hawk Optimizer and Detection of Number Plates

**Amandeep Kaur**
Ph.D Research Scholar, Department of Computer Applications,
CT University, Ludhiana, Punjab, INDIA
e-mail: a.deepmst@gmail.com

**Dr. Sandeep Ranjan**
Professor, Department of Computer Science & Engineering,
CT University, Ludhiana, Punjab, INDIA

**Dr. Harjinder Kaur**
Associate Professor, Department of Computer *Applications*,
AGTMI, Mastuana Sahib (Sangrur), Punjab, INDIA

Abstract— The role of image enhancement is crucial for the processing of images to enhance their quality. Image pre-processing is essential in gathering precise data when detecting any vehicle using its license plate. It requires a method to improve the images to help the persons detect any vehicle and reach the vehicle's owner easily. However most state-of-the-art methods induce different types of distortion such as intensity shift, wash-out, noise and intensity saturation. For this purpose, in this paper, a meta heuristic Modified Fire Hawks optimizer technique has been introduced, which is used to optimize the parameter of Bi-Histogram Equalization with the Adaptive Sigmoid Function method. The pixel and graphic quality of the images are improved with this new technique. Mean square error (MSE), Peak Signal-to-Noise Ratio (PSNR), Mean Absolute Error (MAE), Structural Similarity Index Metric (SSIM), and Absolute Mean Brightness Error (AMBE) are the metrics applied in this paper to check the quality of the processed images. In this paper, main objective of work is to improve the image quality of vehicles and enhancing the image without distortion. This paper is organized in different sections. Section 1 is the introduction section. In section 2, Literature review is presented in which all recent works related to the topic are studied thoroughly. Section 3 describes the methodologies used for the purpose so far and proposed methodology. In section 4, results are shown and compared with the previous results The results of the proposed method are comparatively better than the other state-of-the-art methods for detecting any number of vehicle images. Section 5 briefs the paper and focus on future scope and section 7 describes the various references used for the paper.

**Keywords**- Image processing, Vehicle Number Plate, Fire Hawks Optimizer, MSE, PSNR, MAE

## I. INTRODUCTION

It is now almost impossible to manually identify a vehicle's information, such as its history or the status of any pending traffic tickets. However, in some places, the lack of machinery necessitates manual vehicle inspections. Technology's numerous applications have improved our daily lives in many positive ways. Vehicle and transportation maintenance are laborious and time-consuming tasks. Hand-controlling could expose several problems and shortcomings. For this purpose, an Automatic Vehicle Number Plate Recognition System is needed. Due to the rising demand for residential parking spaces, an effective management-driven solution is required. The majority of people on earth reside in cities, making regular use of secure and practical parking spaces necessary. This system records the information on all permitted vehicles that are registered with the parking system. In many instances, this automatic number plate detection technology is very beneficial. For the past thirty years, numerous researchers have been working on these topics to automate procedures. Efficient road traffic management requires attention as the number of cars rises. For a variety of reasons, including security concerns, it is crucial to develop intelligent vehicle management solutions. Each car has a number plate that serves as the car's identification. The manual registration of automobiles is inconvenient, expensive, and ineffective.

Automatic Number Plate Recognition (ANPR) is the process of reading a number plate from a picture or series of pictures of a vehicle. The ANPR method uses a machine to identify a vehicle identification number. Automatic Vehicle Plate Recognition (AVPR), Automatic Vehicle Identification (AVI), Automatic Licence Plate Recognition (ALPR), Car Licence Plate Detection and Recognition Systems (CLPDRS), Car Plate Recognition (CPR), or simply Licence Plate Recognition (LPR) are some of the other names, have acquired worldwide recognition. In case of resemblance in the background of the Number plate, the recognition of the location becomes more difficult. With the change of light on the number plate its brightness and contrast are also changed. The morphological operations are used to find out the dissimilarity feature within the number plate. ANPR system consists of following steps for number plate recognition. Image processing is the processing of images; it accepts images as input and produces either images or sets of characteristics as its output. This comprises feature detection, noise reduction, picture enhancement, restoration, compression, etc. Noise, blurring, wrong color balance, and poor contrast are constant issues with digital images. These issues can easily influence the majority of digital images created by scanners, digital cameras, video cameras, charged coupled devices (CCD cameras), and webcams. This will produce graphs of poor quality. The

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consequences of these degradations will be reduced by the application of image enhancement [1].

Image enhancement is a technique to make an image finer, higher-frequency features more visible. The goal is to enhance the image's visual details or to offer a "better" transform representation for use in analysis, detection, segmentation, and identification processes that use images. Additionally, it aids in detecting background data necessary to comprehend object behavior in the absence of human vision and perception. Low contrast prevents us from readily distinguishing objects against a dark background. If the color of the items and the background are identical, the majority of color-based techniques will not work in this situation. The two sorts of enhancement strategies are spatial domain techniques and Frequency domain techniques. The spatial technique acts directly on the image's pixels, which contributes to the improvement of contrast. Frequency domain techniques: operates on the corresponding image's Fourier transform. Real-time solutions are implemented in the spatial domain because it is very straightforward, simple to understand, and primarily have a very low complexity range. The two main characteristics that the spatial domain lacks are robustness and imperceptibility. To improve image quality, frequency domain method assessments of functions are carried out concerning frequency. It employs the Fourier transform along with discrete sine and cosine. The orthogonal transforms play a significant role in digital signal/image processing applications and they have the following essential advantages: low computational complexity and easy viewing and manipulation. The alpha-rooting, modified unsharp masking, and filtering transform-based image enhancement approaches that are inspired by the human visual response have been compared. Many professionals worldwide are interested in studying the ANPR because it is a valuable subject matter (Figure 1). It is a particularly challenging job because of the variety of license plates and the uneven lighting during the vehicle image collection.

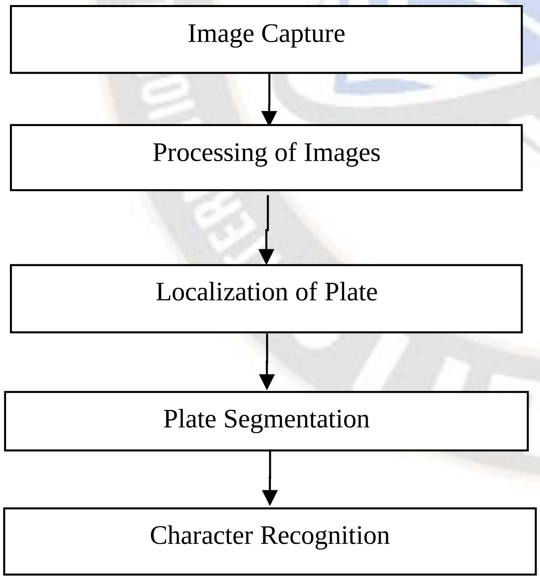


Figure 1**:** Block diagram of ANPR system

## II. LITERATURE REVIEW

Number of researchers worked on Automatic Number Plate Recognition (ANPR) System. [2] proposed a technique for the location and extraction of car number plates in difficult scenes. They presented an algorithm that worked in four main steps: pre-processing, extraction of candidate regions, morphological processing and region merge. The researchers applied the algorithm on real-time images which consists cars in various conditions. This algorithm could also detect the license plate numbers of distorted car plates. [3] presented Sobel filter method to detect edges in the car image. The boundaries of the car plate were represented by edges in the picture. Number Plate of the car was extracted from the picture with horizontal and vertical edge detection. This algorithm succeeded to give 95% results. [4] presented an effective method for license plate identification and detection. They implemented fuzzy for license plate localization and neural method for license plate recognition. The researchers implemented the proposed technique on real-world pictures. They succeeded to get an accuracy rate of 97.9% for license plate detection or localization and 95.6% for license plate number recognition. The overall success rate reported was 93.7%. [5] presented an adaptive segmentation and extraction method based on mathematical morphology operators. Pictures of damaged cars were taken in the researches to assess the robustness and flexibility of the used algorithm. The presented approach had productively performed the automatic segmentation and extraction of characters from the picture.[6] proposed an automatic VLP Recognition and See Car Recognizer system consisting four modules called Pre-processing, VLP detection, character segmentation and optical character recognition (OCR). This system is appealing but not easy to use. The author claimed 98.76% accuracy rate from the images taken at Airport check-in office and rotated 300 angle and some from different random locations rotated left and right or straight. [7] proposed license plate affirmation which expects a basic part in different applications and different systems. In this research, a novel system to see labels is shown.

To begin with, the labels are discovered using eminent components. By then each of the seven characters in labels is segmented ultimately, the character recognizer isolates some astounding components of the characters and uses a part prominence classifier to fulfill healthy recognizer result.[8] proposed a new edge-based car plate detection method to locate and extract car plates from the difficult car images. The researchers tested this system on real CCTV footages having resolution of the video 320*240 with 4 fps frame rate. The algorithm succeeded to locate the car plate with 94% accuracy. [9] developed an algorithm for the purpose of identifying the car licence plate that combines connected component analysis, an adaptive picture segmentation technique, and sliding concentric windows with a character recognition neural network. A two-layer probabilistic neural network was employed for the optical character recognition system, and a trained network was used to detect characters from the image of a car license plate based on the information gathered from algorithmic image processing.[10] presented a novel method for automatic vehicle plate detection. The vehicle number from the plates was automatically taken out and they matched with the given database to recognize the owner of the car. This method had no limitations of distance, color, and single plate. The proposed algorithm was faster and more efficient.

[11] presented a Vertical Edge Detection Algorithm (VEDA) for locating the number plate. This method is based on the contrast between the values of the grey scale. The results were very impressive and showed that VEDA is 7-9 times faster than the Sobel operator. [12]The author proposed an LPR

method which was efficient for Indian License Plates. The method based on morphological algorithms and connected components analysis. The researchers tested the method on images captured under different circumstances and got satisfactory outcomes.[13]presented an LPR system based on Artificial Neural Network (ANN). A quick back propagation learning method used to train the ANN. The three main stages discussed in this method were plate localization, character segmentation and recognizing the segmented characters. The given method was tested on 259 pictures and success rate of all was 95.36%. [14]presented a Neural Network in License Plate Character Recognition System. Still image was used as input to the system. First of all, contrast stretching is used to enhance the image and then Tophat-Bothat used. For detecting the edge, Sobel Operator was used. In order to detect License Plate, Morphological operators were used. Character Segmentation is performed by using the line scanning technique from left to right. Overall, two Neural Network techniques used to recognize the characters are Back Propagation Neural Network (BPNN) and Learning Vector Quantization Neural Network (LVQNN). It is observed by the author that accuracy of LVQNN is better than the BPNN.

[15] created an online real-time intelligent licence plate identification system using the combination of linked component analysis and spectral analysis at the stage of licence plate extraction and segmentation. [16] presented an algorithm in number plate recognition using OCR Technique to recognize the characters on the Number plate. To get a clear image, it clicked from 1 meter from the number plate using a Camera. Then the image is cropped and sent as input to recognize the characters. By using the OCR technique characters are recognized.

## III. METHODOLOGY

A new method has been developed for an automatic vehicle recognition system using an algorithm as per the objectives of the project. For this purpose, the images used were captured using a Realme 7Pro mobile phone with specifications of 6GB of RAM, having a 64-megapixel camera. The dataset utilized in this study comprises a total of 100 images, all of which depict various types of vehicles. These images serve as the primary data source for the research, and they are provided in the .jpg format, a widely used and compatible image format (Figure 2). The research work is broadly divided into three sections.

1. Capturing Images
2. Image Pre- Processing
3. Localization of Number Plate: This process included of three phases
   (a) Binarization and Filtering of Candidate Region
   (b) Positioning Method for Characters

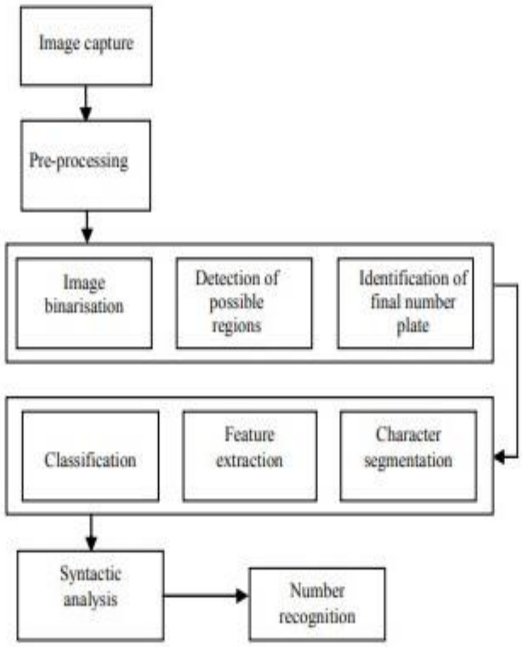


Figure 2: Block diagram of the used system

### *A. Proposed Modified FHO (MFHO) Algorithm for Image Preprocessing*

The prey in the FHO algorithm updates its position even if it is inside or outside the territory of a fire hawk. In the FHO algorithm, the prey outside the territory of the fire hawk moves towards the alternate fire hawk away from the safe palace. This process is improved in the modified FHO algorithm to enhance the exploration and exploitation capabilities of the algorithm. The iterative cosine operator has been used to update the position of the prey. The updated equation for the movement of the prey outside the fire hawk territory is (1)

$$pos_i^{updated} = pos_i \times \cos\left(\pi \times FE / 2 \times MAX_{FE}\right) + (rand_5 \times H_{alter} - rand_6 \times S) \quad (1)$$

where $pos_i^{updated}$ is the updated position, $pos_i$ is the current position, $FE$ is the current fitness evaluation, $MAX_{FE}$ is the maximum fitness evaluations, $H_{alter}$ is the position of the fire hawk, and $S$ is the safe palace outside the territory of fire hawk. The updated position is accepted only if its fitness value is better than the current position fitness value. The $cos\left(\pi \times FE / 2 \times MAX_{FE}\right)$ is the iterative cosine operator which depends on the current $FE$. At initial $FE$ gives higher values which gradually decreases with the increase in the fitness evaluations resulting in exploration at initial fitness evaluations and moving towards exploitation with an increase in fitness evaluations. This improves the exploration as well as exploitation abilities of the FHO algorithm. Overall MFHO algorithm is as follows:

Proposed Algorithm for Image Enhancement (IBEASF ) using MF

**MFHO Algorithm**

1. Generate initial candidate solution from population using Eq.

$$F = \begin{bmatrix} F_1 \\ F_2 \\ \vdots \\ F_i \\ \vdots \\ F_N \end{bmatrix} = \begin{bmatrix} F_1^1 & F_1^2 & \cdots & F_1^j & \cdots & F_1^d \\ F_2^1 & F_2^2 & \cdots & F_2^j & \cdots & F_2^d \\ \vdots & & \ddots & & \vdots & \\ F_i^1 & F_i^2 & \cdots & F_i^j & F_i^d & \\ & & \cdots & & & \\ \vdots & & \ddots & & \vdots & \\ F_N^1 & F_N^2 & \cdots & F_N^j & F_N^d & \end{bmatrix}, \begin{cases} i = 1,2,\ldots,N. \\ j = 1,2,\ldots,d. \end{cases} \quad (2)$$

Where $F_i$ represents the ith solution candidate in the search area; d represents the dimension of the difficulty. The Total number of solution candidates for the problem is represented by N.

2. Compute the fitness value for each member of the candidate solution
3. Compute Universal best using Eq.

$$FRH_1^{new} = FRH_1 + (s_1 \times UB - s_2 \times FRH_{near}), l1,2,\ldots,n \quad (3)$$

where $FRH_1^{new}$ is the new location vector of lth Fire Hawk ($FRH_l$);UB is the universal best result in the search which is the main fire. $FRH_{near}$ is one of the nearer Fire Hawks in the search area. And $s_1$ and $s_2$ are consistently distributed random numbers in the (0, 1) range for determining the actions of Fire Hawks in the direction of the main fire and the other Fire Hawks's locations.

4. Initiate FE=1
5. While FE<MAX FE
   - Select FH and P randomly
   - Compute the distance between FRH and P using Eq.

$$TD_k^l = \sqrt{(f_2 - f_1)^2 + (g_2 - g_1)^2}, \begin{cases} l = 1,2,\ldots..n. \\ k = 1,2,\ldots.,m \end{cases} \quad (4)$$

$TD_k^l$ shows the mean of the above equation, where $TD_k^l$ represents the Total Distance of lth fire hawk and the kth prey. The total number of pry represented by m and n is the total number of fire hawks in the search area. $(f_1,g_1)$ and $(f_2,g_2)$ shows the coordination between the Fire Hawks and prey in the search area.

   - Compute the territory of FRH using Eq. (5)

In the search area$f_i^j$ is the $j^{th}$ choice variable of the $i^{th}$ result candidate; $f_i^j(0)$ represents the initial position of the resulted variable; $f_{i,min}^j$ and $f_{i,max}^j$ are the Minimum and Maximum bounds of the jth choice variable for the ith resulted candidate, and rand is a consistently scattered random number in the range of $[0,1]$.

   - For each FH

   Update the position of FH using Eq. (3)

   - For each P

   Compute S for current FRH territory using Eq.

$$SFP_1 = \frac{\sum_{i=1}^{m} PRY_i}{m} n, \begin{cases} i = 1,2\ldots m. \\ j = 1,2,\ldots n. \end{cases} \quad (6)$$

In this $PRY_i$ is the $i^{th}$ prey bounded by the $j^{th}$ fire hawk ($FRH_l$); $PRY_k$ is the the $k^{th}$ prey in the search location.

   - Update the position of the current P using Eq.

$$PRY_q^{new} = PRY_q + (s_3 \times FRH_1 - s_4 \times PRP_1), \begin{cases} l = 1,2,\ldots,n, \\ q = 1,2,\ldots,s, \end{cases} \quad (7)$$

   - Compute S outside the current FH territory using Eq.

$$SFP = \frac{\sum_{k=1}^{p} PRY_k}{p}, k = 1,2,\ldots,p \quad (8)$$

   - Update the position of the current P using Eq. (7)

   End for

   End for

   Compute fitness for each FH and P

   Update Universal best

   End while

6. Return Universal Best

### B. *Proposed Algorithm for Image Enhancement (IBEASF ) using MFHO*

This work proposes IBEASF by improving the BEASF i.e., Bi-Histogram Equalization with Adaptive Sigmoid Functions technique. IBEASF method works in three phases i.e., histogram splitting, sigmoid transform creation, and mapping, like the BEASF algorithm. In the histogram splitting phase, two sub-histograms are created by selecting a splitting point based on the mean intensity of the image. Two sub-histograms are collections of points having a density less and higher than the mean image intensity. In the sigmoid transform creation phase, two sigmoid functions are created with origin at the median of the two sub-histograms generated in phase 1. The sigmoid function values depend upon the origin and the $\gamma$. The $\gamma$ value is selected using the MFHO algorithm discussed in the previous section, to generate a better-enhanced image. The objective function used in the MFHO algorithm uses the Structure Similarity Index Measure (SSIM) to compare the original and the enhanced image. This work uses three different SSIMs namely Jaccard similarity, cosine similarity, and the Chebyshev distance, to design three variants of the IBEASF algorithm. Three different objective functions corresponding to three SSIMs i.e., Jaccard similarity, cosine similarity, and the Chebyshev distance, are given by Eq. (9), (10), and (11).

$$OB_1^{jaccard} = 1 - \frac{|OI \cap EI|}{|OI \cup EI|} \quad (9)$$

Where $OI, EI$ represents the original and the enhanced image used to generate first objective function using Jaccard similarity $OB_1^{jaccard}$.

$$OB_2^{cosine} = 1 - \frac{\sum_{p=1}^{n}(OI_p\, EI_p)}{\sqrt{\sum_{p=1}^{n} OI_p^2}\sqrt{\sum_{p=1}^{n} EI_p^2}} \quad (10)$$

where n is the total number of pixels in the image $OI$ as well as in $EI$.

$$OB_3^{chebychev} = MAX\left(\left|OI_p - EI_p\right|\right)\ \forall p = 1\ to\ n \quad (11)$$

Where $OB_3^{chebychev}$ is the objective function based on chebychev distance between $OI, EI$ i.e., original and enhanced image.

**IBEASF Algorithm**
**Input**: Original Image (**OI**)
**Output:** Enhanced Image (**EI**)

1. Compute Mean intensity say mi of OI using

$$X = \begin{bmatrix} X_{0,0} & X_{0,1} & \cdots & X_{0,N-1} \\ X_{1,0} & X_{1,1} & \cdots & X_{1,N-1} \\ \vdots & \vdots & \ddots & \vdots \\ X_{M-1,0} & X_{M-1,1} & \cdots & X_{M-1,N-1} \end{bmatrix} \quad (12)$$

$$mi = \frac{\sum_{r=0}^{M-1} \sum_{c=0}^{N-1} X(r,c)}{MN}$$

Where X is an input image of size M*N

2. Generate Histogram of OI say $H_{OI}$ $\quad H_{OI} = H_L \cup H_U \quad (13)$

3. Compute $H_{OI}^U$ and $H_{OI}^L$ from $H_{OI}$ using $\quad H^L{}_{OI} = \{H_0, H_1, \ldots, H_m\}$, $H^U{}_{OI} = \{H_{m+1}, H_{m+2}, \ldots, H_{l-1}\} \quad (14)$

4. Compute probability density function and cumulative density function say $P_{OI}^U$, $P_{OI}^L$ and $C_{OI}^U$, $C_{OI}^L$ for $H_{OI}^U$ and $H_{OI}^L$ respectively using

$$P(k) = \begin{cases} \dfrac{H^L{}_{OI}(k)}{\sum_{n=0}^{mi} H^L{}_{OI}(n)} & \text{if } k \le mi \\ \dfrac{H^U{}_{OI}(k)}{\sum_{n=mi+1}^{l-1} H^U{}_{OI}(n)} & \text{if } k > mi \end{cases} \quad (15)$$

6. Compute $\gamma$ using MFHO algorithm and objective using Eq. (9) or (10) or (11).
7. Generate Sigmoid function say $SF$ using Z(k) and $\gamma$ using

$$SF(k) = \begin{cases} \dfrac{1}{1+e^{-\gamma z(k)}} & \text{if } k \le mi \\ \dfrac{1}{1+e^{-\gamma z(k)}} & \text{if } k > mi \end{cases} \quad (17)$$

8. Perform histogram equalization using

$$u(k) = \begin{cases} u^L{}_{OI} = L_0 + (mi - L_0)SF(k) & \text{if } k \le mi \\ u^U{}_{OI} = mi + (L_f - m)SF(k) & \text{if } k > mi \end{cases}$$

9. Perform stretching to get EI by using

$$a^L{}_{OI} = \frac{(mi - L_0)}{max(u^L{}_{OI}) - min(u^L{}_{OI})}$$

$$a^U{}_{OI} = \frac{(L_f - mi)}{max(u^U{}_{OI}) - min(u^U{}_{OI})} \quad (18)$$

$$T(k) = \begin{cases} L_0 + a^L{}_{OI}(u^L{}_{OI}(k) - min(u^L{}_{OI}))\text{when} k \le mi \\ m + a^U{}_{OI}(u^U{}_{OI}(k) - min(u^U{}_{OI}))\text{when} k > mi \end{cases}$$

10. Return Enhanced Image EI

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## IV. RESULTS OF PREPROCESSING

We have used the above proposed procedure to enhance the images of vehicles taken with the mobile camera. Then, we compared the enhanced images and histograms of these images with other state-of-the-art procedures like histeq, optimal gamma, Bi-Histogram Equalisation with Adaptive Sigmoid Function (BEASF), Dynamic stretching averaging histogram equalization (AVHEQ).

### *A. Comparison of Histogram of Proposed Algorithm with other algorithms*

We Created the histograms of different images using our proposed algorithm and compare it with the existing algorithms. We find the better results of Histograms using our algorithm as compared to others as shown in below screen shots from figure 3 to figure 10:

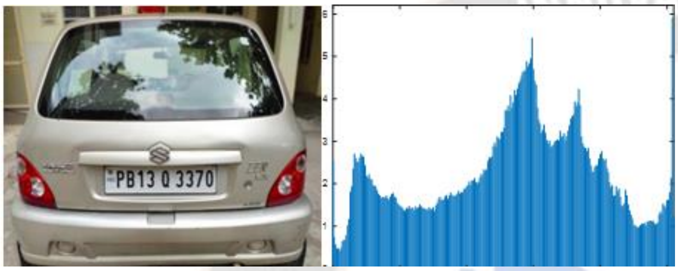

Figure 3: Original Image of Car and its histogram

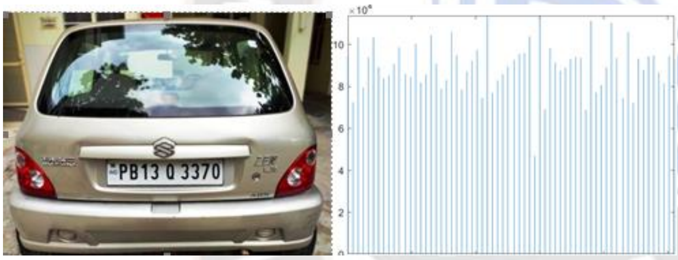

Figure 4: Histeq Enhanced Image and its Histogram

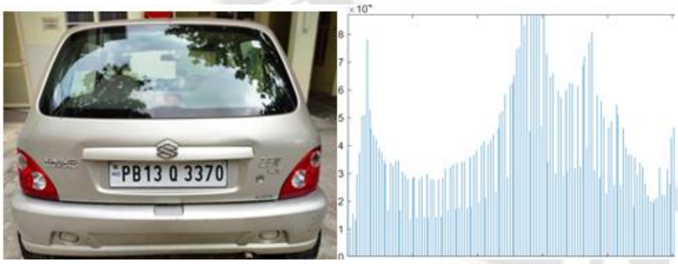

Figure 5: BEASF Enhanced Image and its Histogram

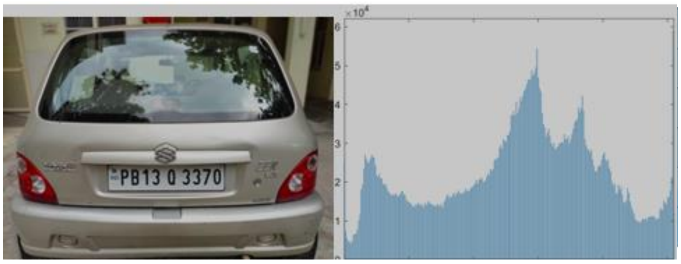

Figure 6: Optimal gamma Enhanced Image and its Histogram

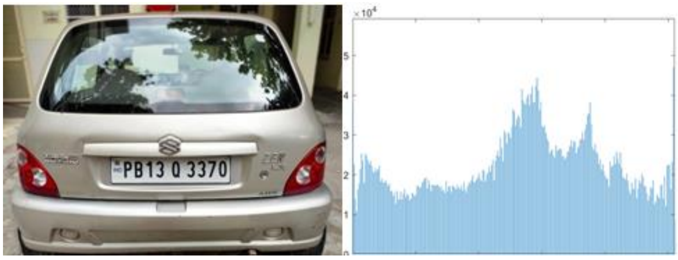

Figure 7: Dynamic Stretching Enhanced Image and its Histogram

Figure 8: Image Averaging Histogram Equalization and its Histogram

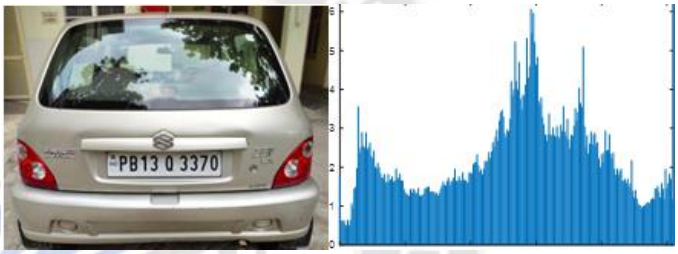

Figure 9: HisSpecif Enhanced Image and its Histogram

### *B. Quantitative* assessment

Image enhancement, often known as improving the visual quality of a digital image, is a subjective technique. The finding of a single technique that produces a higher quality is an issue because everybody has different images. So, comparing metrics methods for picture enhancement and their effects on image quality are necessary for an accurate analysis. MSE or Mean Square Error, Mean Absolute Error (MAE), Peak Signal Noise Ratio Features(PSNR), Structural Similarity Index Metric (SSIM)Based on the Similarity Index Metric for quantitative evaluation, Absolute Mean Brightness Error (AMBE) is used in the proposed approach. In the quantitative evaluation, 100 images of Cars were captured and evaluated from figure 11 to figure 15 and Table 1

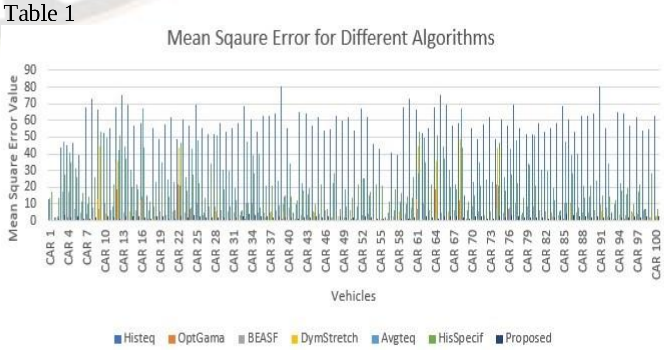


Figure 11: Comparison Chart-MSE

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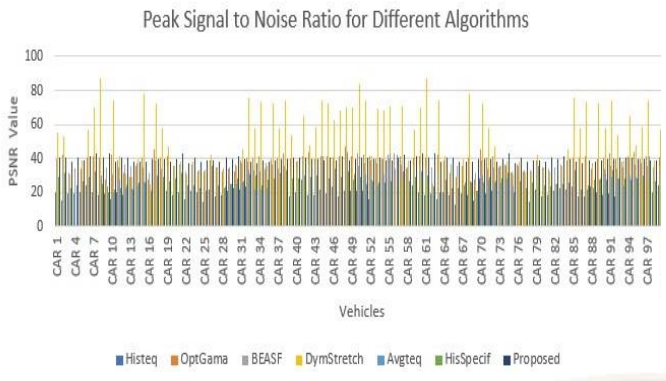


Figure 12: Comparison chart-PSNR

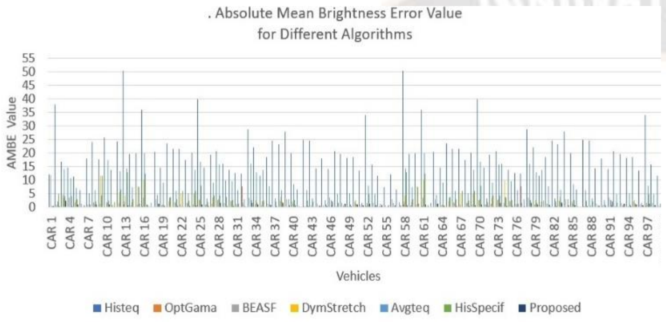


Figure 13: Comparison Chart-AMBE

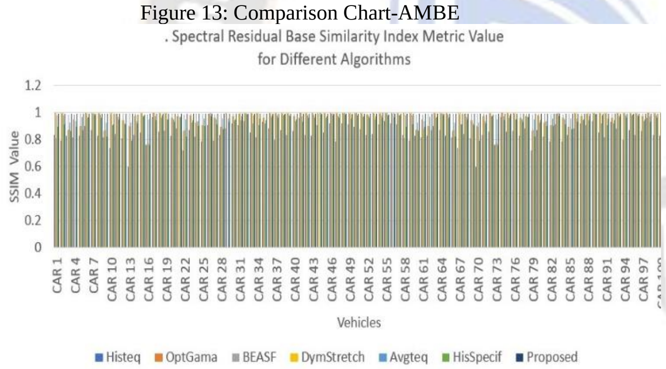


Figure 14: Comparison Chart-SSIM

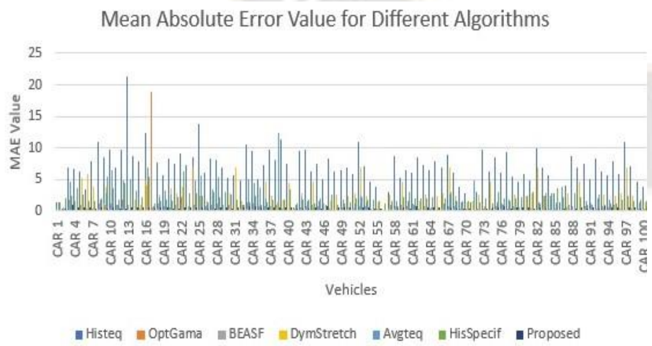


Figure 15: Comparison Chart-MAE

## V. IMPLEMENTATION AND RESULTS

In Pre-Processing, after clicking the images, these images were enhanced using the modified fire hawk optimization (MFHO) technique as discussed in section 3. Image filtering techniques and morphologic operators are applied to highlight the number region on the number plate. In post-processing, simple if-else-based rules are applied to validate the rules and regulations for a sequence of characters in the number plate. Overall, the system is proposed for number plate recognition using MatLab ( for preprocessing) and Python for post processing as defined by the objectives.

### *A. Hardware and Software Requirements for preprocessing*

Hardware Requirements:

1. Camera or Image capture device.
2. Computer or processing unit.
3. Memory/Storage space.
4. Network connectivity.
5. Power supply and Backup.
6. Environmental considerations.

Software Requirements:

1. Operating System
2. Image processing libraries.
3. MatLab
4. Optical character recognition software.
5. Development and Debugging tools.

### *B. Algorithm used to detect the Number Plate of a Vehicle*

**1.** Importing Libraries: The script imports necessary libraries like OpenCV, NumPy, PIL (Python Imaging Library), by tesseract, and re (regular expressions).

**2.** Number Plate Detection Function (number_plate_detection):

- This function takes an image (img) as input.
- It applies various image processing techniques like Gaussian Blur, Sobel edge detection, thresholding, morphological operations, contour detection, etc., to detect the number plate region in the image.
- Once the number plate region is detected, it performs some checks (like aspect ratio, white pixel density, etc.) to ensure it's a valid number plate. Finally, it extracts the number plate region, cleans the image, and uses Tesseract OCR to recognize the characters on the number plate.

**3.** Quick Sort Implementation (quickSort):
This function sorts an array of strings (presumably representing vehicle numbers) using the Quick Sort algorithm.

**4.** Partition Function (partition):
This is a helper function used in Quick Sort to partition the array.

**5.** Binary Search Implementation (binarySearch):
This function searches for a given vehicle number in a sorted array of vehicle numbers using the Binary Search algorithm.

**6.** Main Execution:

- It iterates through a directory containing images (Images/*.jpg), displays each image, detects the number plate, and extracts the vehicle number.
- Detected vehicle numbers are stored in an array.
- The array of vehicle numbers is sorted using Quick Sort.
- Then, it iterates through another directory (search/*.jpg), where images of vehicles to be searched are stored.

For each search image, it detects the number plate, extracts the vehicle, and performs a binary search to check if the vehicle is allowed to visit based on whether its number is in the registered list.

Output:

The script prints the detected vehicle numbers, a sorted list of registered vehicle numbers, and the search results for each vehicle. This algorithm essentially performs the task of detecting number plates from the vehicles, recognizing characters on them, sorting the registered vehicle numbers, and searching for a given vehicle number for the required purpose.

Table 1: Average Values of Performance Evaluation Metrics

| Average Evaluation | Histeq | OptGama | BEASF | DymStretch | Avgteq | HisSpecif | Proposed |
|---|---|---|---|---|---|---|---|
| **MSE** | 53.7402 | 1.7906 | 5.9118 | 4.5746 | 23.1104 | 20.3247 | **1.9948** |
| **PSNR** | 19.8666 | 38.2820 | 35.6515 | 53.9032 | 28.0937 | 26.1829 | **39.6890** |
| **AMBE** | 19.2208 | 0.2122 | 1.7124 | 1.7842 | 6.4008 | 2.7844 | **0.6618** |
| **SSIM** | 0.8536 | 0.9730 | 0.9891 | 0.9740 | 0.9616 | 0.9400 | **0.9916** |
| **MAE** | 7.2824 | 0.8111 | 0.8229 | 2.1562 | 3.4227 | 2.0130 | **0.4573** |

### *C. Results and Screenshots of MATLAB*

Results are shown from figure 16 to figure 19.

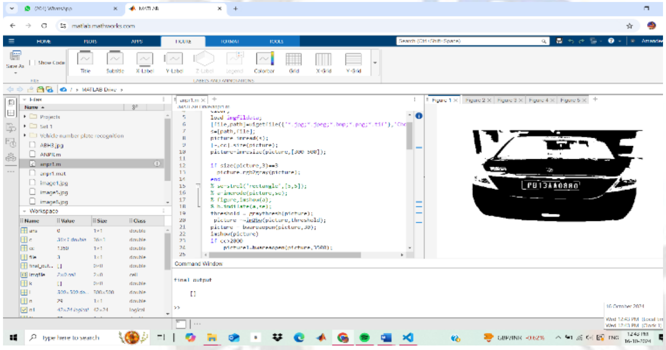

Figure 16: Input Image for Detection of Possible Region of Number Plate

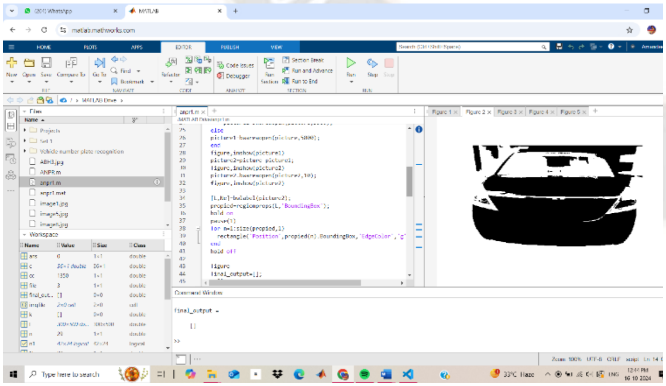

Figure 17: RGB to Grey Scale Conversion of Input Image

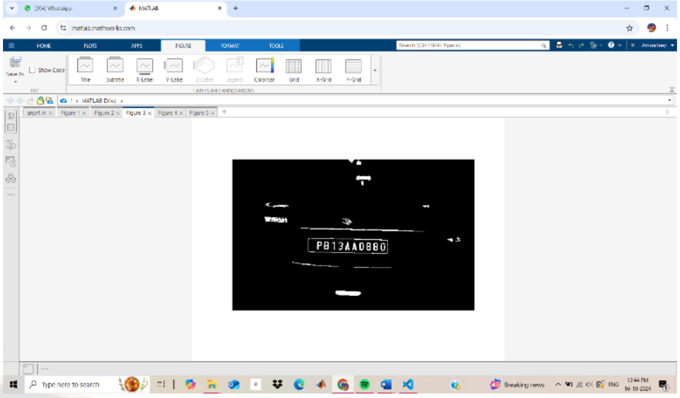

Figure 18: Detection of Possible Region of Number Plate

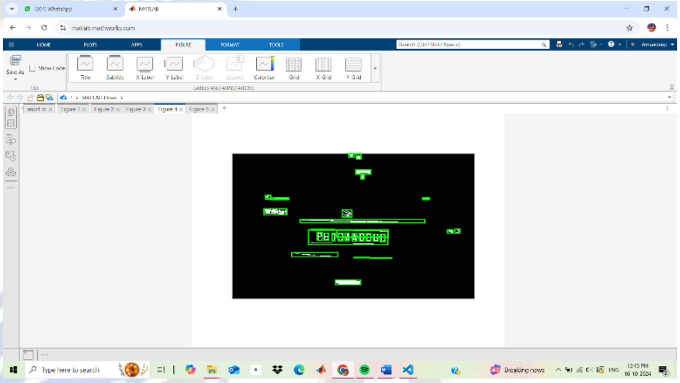

Figure 19: Segmentation of Characters of Number Plate

### *D.* Results and *Screenshots* of Python

After preprocessing the input vehicles using MATLAB, we finally process the images for detection of numbers on the number plates. For this purpose, 4 different set of images are used. Out of these 4, two sets are of original images of vehicles at different locations, 3rd set is of Enhanced images using our proposed algorithm above in section 3 and 4th set is of vehicle are the images downloaded from internet. Oher than detection of numbers on the number plate, our algorithm also stores the number in Ascending Order as shown in figure 20 to figure 27.

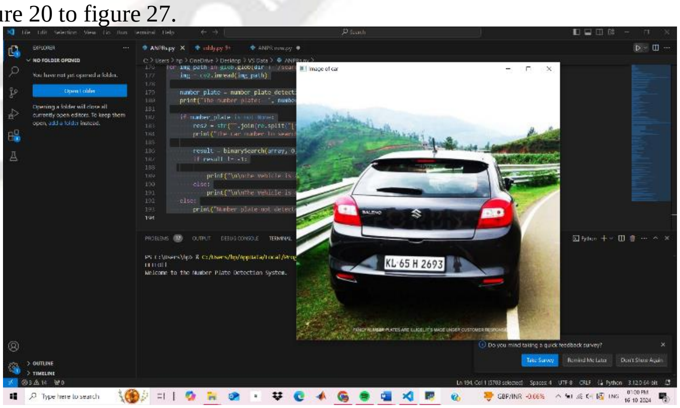

Figure 20: First Input Vehicle

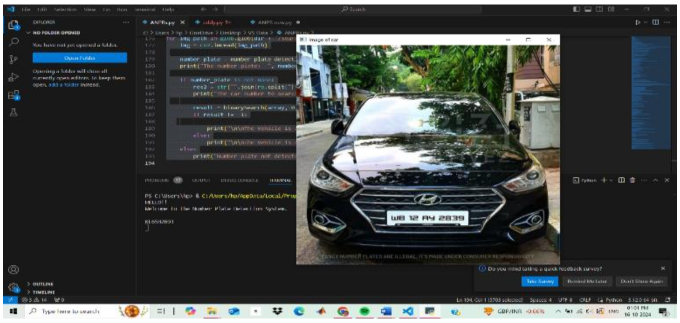

Figure 21: Number Detection of First Vehicle(L) and Second Input Vehicle (R)

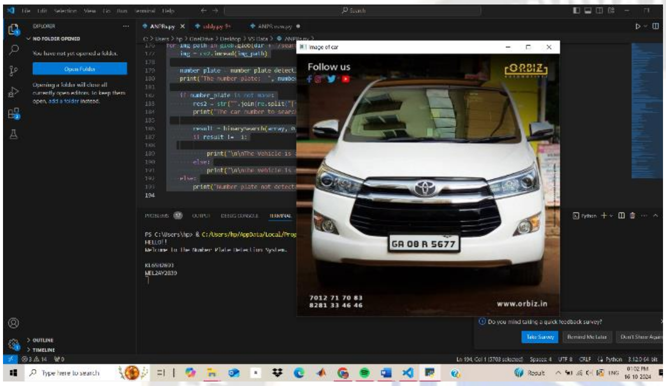

Figure 22: Number Detection of Second Vehicle(L) and Third Input Vehicle(R)

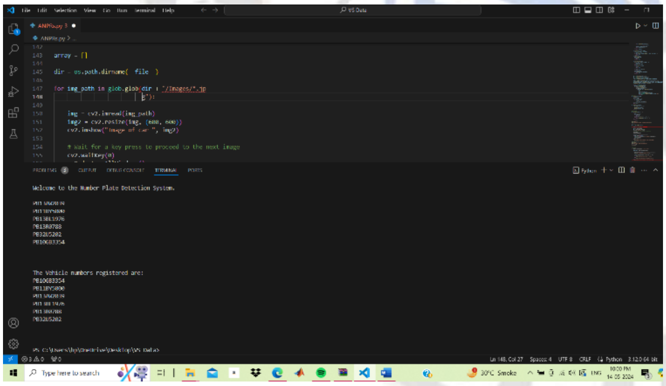

Figure 23: Set-1 Results ( Original Images- Location 1)

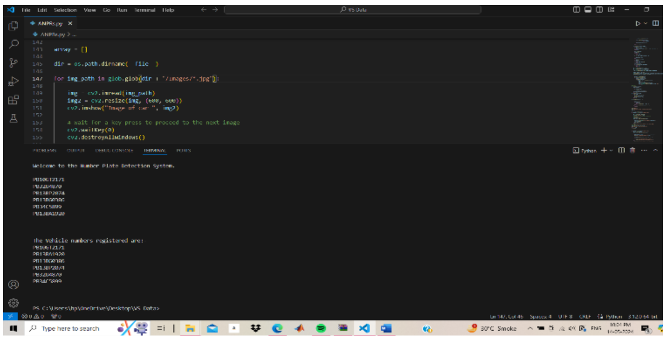

Figure 24: Set-2 Results ( Original Images- Location 2)

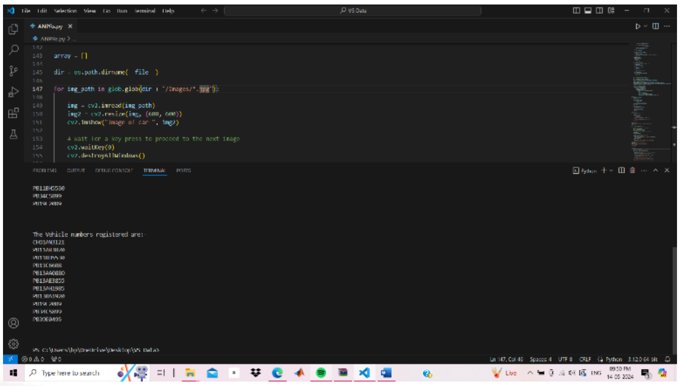

Figure 25: Set-3 Results (Enhanced Images)

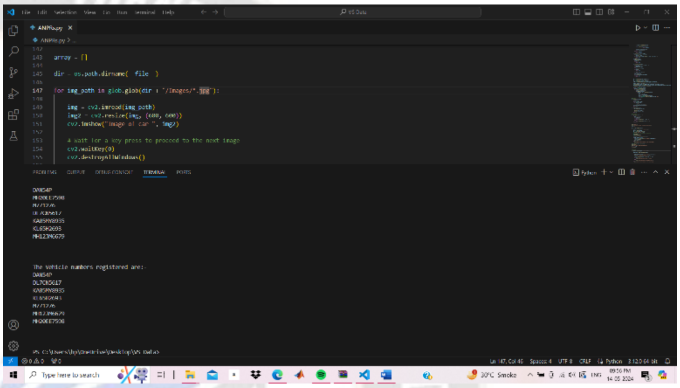

Figure 26: Set-4 Results (Downloaded Images)

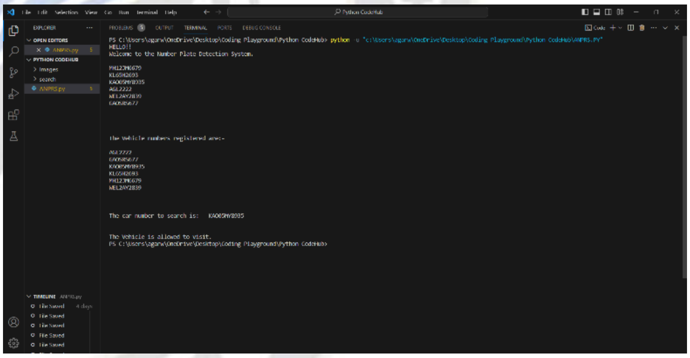

Figure 27: Detected Number Plates sorted in Ascending Order

Output:- Program runs successfully. It reads all the vehicle's number plates and sorts them in ascending order. Search the desired number plate from the collected data and show successfully whether vehicle is allowed to enter the parking region or not.

## VI. CONCLUSION AND FUTURE SCOPE

Vehicles are an essential part of transportation, and because of their many advantages, their use has increased dramatically. This leads to an interesting computer vision and pattern recognition problem with automated vehicle monitoring. Every car has an external component known as a number plate that acts as the vehicle's identification. As a result, the process of identifying car license plates must be automated. Essentially, an ANPR system uses a camera to take a picture of the car in order to scan number plates. Identifying, detecting, and recognizing a number plate number from an input image of the vehicle is one of ANPR's primary tasks. The state-of-the-art in ANPR has advanced significantly over the last ten years. Automatically recognizing license plates from moving cars is essential for surveillance systems. These technologies improve the quality of transportation systems overall and assist human operators. Parking lots, highways, bridges, and tunnels all use them. ANPR, a method of broad monitoring, uses optical character recognition on images to read license plates of vehicles. It is a technique for recognizing automobiles based on their license plate numbers. It is a technique for taking out the license plate number from a moving car in an image or video. Because it is essential to so many applications, the ANPR system saves time by handling vehicle data without requiring human intervention. There are no longer any shortcomings that a manual method would have brought about. Data, including images and videos, can be recorded with a digital camera. This data, which includes images and videos, is received by the ANPR system. After the algorithm is run over the input data, the ANPR system generates the registration number that shows on the car's license plate.

Section 1 Introduction describes the working of ANPR system. Process of ANPR system which includes Image Capturing, Image Enhancement, Processing of images, Localization of Plate, Plate Segmentation, Character Recognition. Further Techniques for ANPR consists Plate Localization, Plate Orientation and Sizing, Normalization, Character Segmentation, Optical Character Recognition, Syntactical/Geometrical analysis. Moreover, Features of the ANPR system having options Quick recognition, High character recognition accuracy, High degree of uniformity. The six primary stages of the ANPR technique typically are data collecting, preprocessing, plate extraction, plate segmentation, character recognition, and vehicle number. Applications of ANPR having Security, Automated toll collection, Parking, Border control, Gas stations, Recovery of stolen vehicles, to determine whether the car is licensed or registered,

Section 2 Literature Review describes Number of researchers has worked on the topic Automatic Number Plate Recognition (ANPR) System. The literature review chapter covers the research that these scientists have completed.

In Section 3, a mechanism for Vehicle images enhancement technique has been developed. Visual inspection and metrics related to image quality have been used in the enhancement analysis. The FHO is modified using a thorough learning technique to obtain the ideal value for the sigmoid function's smoothness factor. The sigmoid function's optimal value improves the quality of the vehicle images. The suggested approach was tested using vehicle pictures taken via the mobile camera. The values of MSE, PSNR, MAE, SSIM, and AMBE have been calculated and examined to validate the approach. The suggested work has significantly improved the image quality performance measures when compared to other state-of-the-art methods. Improved image quality will result in improved textural, intensity, and form characteristics that aid in the precise identification of vehicle number plates. The suggested approach obtains the top rank, demonstrating its usefulness in real-world situations.

In Section 4, implementation of the algorithm is discussed that essentially performs the task of detecting number plates from the vehicles, recognizing characters on them, sorting the registered vehicle numbers, and searching for a given vehicle number for the required purpose. The script prints the detected vehicle numbers, a sorted list of registered vehicle numbers, and the search results for each vehicle. Although our algorithms improve the previous one’s but still there is a future scope for the researchers in this field. The main point where researchers can focus is the speed of vehicle. We didn’t consider the speed of vehicle and just enhanced the still images and detect the number. So capturing the moving vehicle number plate and detecting the number is a challenge and can be considered for future scope.

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