AUTOMATIC NUMBER PLATE RECOGNITION SYSTEM

Project report submitted in partial fulfillment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

IN

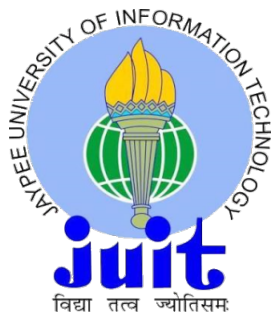
ELECTRONICS AND COMMUNICATION ENGINEERING

By

Divyansh Parmar (161101)

UNDER THE GUIDANCE OF

Dr. Nishant Jain



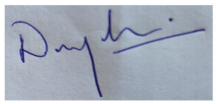
JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

May 2020

TABLE OF CONTENTS

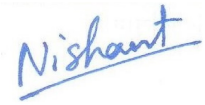
DECLARATION

I hereby declare that the work reported in the B.Tech Project Report entitled **"AUTOMATIC NUMBER PLATE RECOGNITION"** submitted at **Jaypee University of Information Technology, Waknaghat, India** is an authentic record of our work carried out under the supervision of **Dr. Nishant Jain.** I have not submitted this work elsewhere for any other degree or diploma.



Divyansh Parmar
161101

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.



Dr. Nishant Jain
Assistant Professor
Jaypee University of Information Technology
Waknaghat, Distt.- Solan,
Himachal Pradesh

Date: 25th May, 2020

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my supervisor **Dr. Nishant Jain** for the continuous support of my thesis study, for his patience, motivation, enthusiasm and immense knowledge which helped me in the successful completion of my project on '**Automatic Number Plate Recognition System**'. His guidance and constant supervision have helped me during the entire study and writing of this report. I would also like to thank him for lending me his precious time whenever I approached him with any problems or doubts.

I am thankful to **Prof. Dr. M. J. Nigam,** Head of Electronics and Communication Department, for all the support.

I am also very thankful to all the faculty members of the department, Lab Engineer **Mr. Pramod Kumar** for their constant encouragement during the project.

Last but not the least I would like to thank my parents, who taught me the value of hard work by their own example.

Date: 25th May, 2020

LIST OF ACRONYMS AND ABBREVIATIONS

LP	License Plate
ANPR	Automatic Number Plate Recognition
NP	Number Plate
OCR	Optical Character Recognition/Reader
PDF	Probability Density Function
FPGA	Field Programmable Gate Array
ARM	Advanced RISC machine
RISC	Reduced Instruction Set Computing
VHDL	VHSIC Hardware Description Language
VHSIC	Very High-Speed Integrated Circuit
ROI	Region of Interest

LIST OF FIGURES

i. Reference/Standard Figure containing text
ii. Dilation of text in reference figure using Dilation Function

Fig2.13: Dilation of an object using structuring element
i. Reference/Standard Figure containing text
ii. Dilation of text in reference figure using Dilation Function

Fig2.14: Erosion of an object using structuring element
i. Reference/Standard Figure containing text
ii. Erosion of text in reference figure using Erosion Function

Fig2.15: Erosion of an object using structuring element
i. Reference/Standard Figure containing text
ii. Erosion of text in reference figure using Erosion Function

Fig2.16: Convolution (Brightening)
i. Original Image
ii. Brightened Image using convolution

Fig2.17 : Elimination of horizontal linesat the edges of number plate
i. Number Plate with horizontal edges
ii. Removal of horizontal lines

Fig2.18: Elimination of possible horizontal lines, via erosion function using line structuring element, from the output image of region grow that could possibly be the horizontal edges(borders) of the license plate.
i. License Plate Image with Horizontal Lines and irrelevant objects
ii. Erosion function to remove horizontal border lines through line structuring element
iii. Removal of the existing horizontal lines/horizontal borders of the License Plate

Fig2.19: Character Filling, Character Thinning and Erosion is performed

i. License Plate Image with gaps in the characters, thick characters that are joined via small strokes and small background elements
ii. License Plate with filled gaps in characters, thinning of characters to ensure reduced connected strokes between them for better character isolation and removed small background elements

Fig2.20: Object Reduction

i. NP with irrelevant objects
ii. Reduction of irrelevant objects

Fig2.21: Object Reduction is done to remove the irrelevant regions/objects from image

i. Regions having pixels more than certain value are selected for bounding box
ii. Regions having area less than certain threshold value removed to eliminate irrelevant objects

Fig2.22 : Character Segmentation

i. NP Image after Object Reduction
ii. Segmentation of Number Plate Characters

Fig2.23: Segmentation of Characters after the reduction of irrelevant objects

i. Characters only visible after the object reduction
ii. The segmentation of characters present in the number plate image

Fig2.24 : List of templates stored in data base

Fig2.25: Template matching to obtain the vehicle number

Fig2.26 : Number of vehicle obtained in Text File, the car Image is aquired froma natural scenario. After application of Image Processing and OCR, the vehicle number is displayed in text file

Fig2.27: Vehicle Number displayed in text file

Fig3.1: Sequential outputs of 1st Image

i. Reading and resizing the image
ii. RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
iii. Eroded Image for eliminating Horizontal Lines
iv. Character Filling, Character Thinning and Image Erosion to remove small elements
v. Object Reduction
vi. Segmentation
vii. Vehicle Number Displayed in Text File

Fig3.2: Sequential outputs of 2nd Image

i. Reading and resizing the image
ii. RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
iii. Eroded Image for eliminating Horizontal Lines
iv. Character Filling, Character Thinning and Image Erosion to remove small elements
v. Object Reduction
vi. Segmentation
vii. Vehicle Number Displayed in Text File

Fig3.3: Sequential outputs of 3rd Image

i. Reading and resizing the image
ii. RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
iii. Eroded Image for eliminating Horizontal Lines

iv. Character Filling, Character Thinning and Image Erosion to remove small elements
v. Object Reduction
vi. Segmentation
vii. Vehicle Number Displayed in Text File

Fig3.4: Sequential outputs of 4^{th} Image

i. Reading and resizing the image
ii. RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
iii. Eroded Image for eliminating Horizontal Lines
iv. Character Filling, Character Thinning and Image Erosion to remove small elements
v. Object Reduction
vi. Segmentation
vii. Vehicle Number Displayed in Text File

ABSTRACT

Automatic Number Plate Recognition System (ANPR) is a real-time machine-intelligent system which identifies the characters from the image of the number plate directly. Owing to the development of technology, crucial research and the increasing use of vehicles; the need for a machine oriented monitoring and recognition system is of immense importance. This technology has become a major requirement and is playing a crucial role in a vast sea of applications. [1]

The increase of unlimited number of vehicles has led to an increased inclination towards Traffic Control and Implementations, Monitoring and Tracking stolen vehicles, Tolling, Management of Parking Lots, Border and Customs Checkpoints etc which has catalyzed the research interest in the field of ANPR Systems. Research on this was also led due to the transportation systems which were difficult to manage and monitor.

Yet it becomes a very challenging problem, due to the diversification in plate formats, scales, irrelevant objects in number plates and non-uniform illumination conditions during image acquisition. To overcome these problems, we make use of the **ANPR** which uses a series of image processing techniques to obtain the number of the vehicle in a text format, starting from the acquisition of vehicle image. The acquired image clearly includes the number plate area which the Region of Interest.

The image goes through 3 major sequence of steps in ANPR systems, which are

i. Image acquisition via high speed cameras.
ii. Implementation of image processing techniques such as filtering; application of morphological operations etc.
iii. Optical Character Reader which uses Object Reduction through boxarea function, Segmentation and Template Matching.

ANPR intends to make the human problems simple by its efficient processing thereby decreasing the human effort required. Effective and Efficient methods help in making the vehicle identification easy. It is a fast and cheap system which increases its chances of adoption by the Government Agencies on a large scale for its real time applications. The system might result in complex variations due to diverse effects like rain, uneven illumination, rotation of plate, fog. The main objective here is the designing of a system which can solve practical problems of vehicle identification in real scenario.

CHAPTER 1
INTRODUCTION

The fast urbanization and enhanced road networks over the last few decades have resulted in the emerging need of efficient monitoring systems for the management of road traffic. The primitive techniques for traffic monitoring which includes EM microwave detectors, inductive loops, sensors have shortcomings. Being bulky they fail to detect slow vehicles/vehicles that have temporarily stopped. Moreover their installation demands the disruption of traffic at the time of installation and maintenance as well. On the other hand, systems that are based on imaging can be easily installed and use the pre- existing infrastructure used in traffic surveillance. Adding to the edge, they can be upgraded with more flexibility for redesigning the entire system by simply updating the system algorithms.

The Automatic number plate recognition (ANPR) is a method of mass surveillance which uses OCR on the image of the number plate to extract the characters present on it. ANPR was first developed at the Police Scientific Development Branch, Britain in the year 1976. The earliest apprehension through detection of a stolen car and the first chronicled case of ANPR was used as an aid in solving a murder case in Bradford, UK. Objective is to design an efficient, effective and authorized identification system with an ability to automatically extract and recognise characters from an image simply by translating the pixels into characters that are numerically readable.

ANPR can also be used to store vehicle images that are encapsulated from the high speed cameras as well as obtain the text on the number plate(Different configurations can even allow us to capture the image of vehicle pilot). ANPR Sytems can also be integrated with the face recognition softwares and can be connected to the nations's population identity database, which can help in not only the identification of the

vehicle but also the identification of the driver, which can help in making the traffic law enforcement more and more secure and less dependant on the manpower.

Most commonly these systems make use of infrared lighting to take the pictures of vehicles using the cameras, not only during day time but also in the night hours. A powerful flash can also be included in the cameras which serves not only the purpose of illuminating the picture but also making the offender aware of the fault he/she has committed. ANPR technology is region-specific because of the place to place variation in the number plate. These systems arecost efficient as they are software based. Practical implementation also requires less cost as the traffic monitoring cameras have been already installed. All we need to do is to connect them with our efficient ANPR Systems. These systems can be operated from anywhere and they merely require a simple PC for the successful implementation

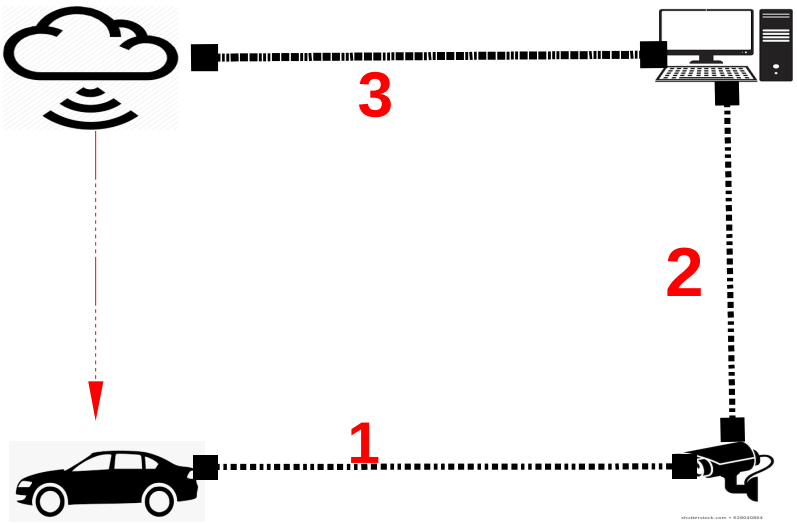


Fig1.1: Full Process of ANPR System
1.Image Acquired
2.Image accessed by Image Processing tools
3.Data compared with the stored database
4.Vehicle Identifica00tion

The process involved in the ANPR systems can be broadly divided into three main steps which are further subdivided for better understanding approach. The basic process of ANPR System comprises of three broad sections which are mentioned below:

i. **Image Acquisition:** Deals with acquiring the image of the vehicle.

ii. **Image Processing:** Deals with the implementation of image processing techniques to obtain enhanced image for better results.

iii. **Optical Character Reader:** Deals with the reading of the characters present on the vehicle number plate image.

1.1 LITERATURE REVIEW

In the past several years, an increased interest has been observed in extracting the text from the number plate image. Extraction of text from image could help us in knowing about the various details of the of image or object source. More research work in the field of ANPR system was observed due to the increasing vehicles, road accidents and traffic laws violation and most importantly the technology.

ANPR was first developed at the Police Scientific Development Branch, Britain in the year 1976. Prototype of this system came into operation in 1979. Contracts were given for the development of industrial systems, firstly at EMI Electronics, and later at the Computer Recognition Systems (CRS) in Wokingham, UK. A1 Road and at the Dartford Tunnel were first to be deployed with Early trial systems. ANPR became widely used only after the new inventions in easier and cheaper to use software were instigated in

1990s. The data collection of ANPR for solving unidentified offence/crime was chronicled in the early 2000s.

- ANPR System helped to make the earliest apprehension through the identification of a stolen car in the year 1981.

- The first chronicled case using ANPR helped to solve a murder that took place at Bradford, UK in November 2005. ANPR also played a prominent role in detecting and subsequently sentencing the killers of Sharon Beshenivsky. [15]

Zoe Jeffrey, Xiaojun Zhai et al., proposed a methodology of Automatic number plate recognition system which was based on ARM- DSP [16]. DSPs are the most widely used in audio, speech, image, video and wireless signal processing applications. Increased development of FPGAs is an alternate to low cost accelaration for computationally intensive tasks .Most of the applications for ANPR systems uses ARM, DSPs, FPGA depending upon cost effectiveness, power consumption to processing power offered, creation of a custom architecture for different requirements.

The performance of these processors depends greatly on their execution. It might take a longer time to work properly, if they are not executed properly by the programmer.

➔ M. Sheppard's, GISMO A Robot Reader Writer, proposed a modern OCR technology which was invented in 1951. [16]

➔ According to Sorin Draghici et al., an artificial neural network based artificial vision system is able to analyze the image of a car given by a camera, locate the registration plate and recognize the registration number of the car.[16]

➔ The system proposed by Sorin Draghici et al., which was designed using a modular approach which allowed easy upgrades and substitutions of variety of submodules thereby making it potentially suitable in a large range of vision applications. An interchangeable plug-in module was designed in the name of OCR engine. [16] The introduction of interchangeable engine allowed the user to choose suitable OCR depending upon the application and to easily upgrade it.

➔ Leonard G.C.Hamy et al., has demonstrated the recognition of the number plates (LP or registration plates) of Australian vehicles. [16] This system had to cope with variation in the number plate depending upon the state to which it belonged(Font ,Plates of non standard material), which made it complex. It incorporated a combination of Image Processing and Neural Network Technology

➔ Serkan Ozabay et al., claimed that the ANPR finds its applications in various traffic violation systems. In their work, a very simple and smart algorithm was presented for the identification of LP. The presented algorithm was subdivided into three phases-

1. **Extracting the plate region**- Edge Detection and smearing algorithm

2. **Segmenting the characters-**Smearing algorithm, filtering and some morphological algorithms

3. **Recognizing the Characters present**- Template Matching

➔ Halina Kwasnicka et al., has described an approach for the recognition and localization of the license plated. [16] Two independent methods were used for the localization of license plate. The first method was based on connected component analysis and in second method license plate “signature was searched in the image”, A simple neural network was finally used to identify them. Vertical projection was

used for segmentation and a syntax analysis was used to separate correct number plate from other captions.

➔ According to Hyo Jong Lee et al., the recognition of vehicles by all the features has not been properly studied owing to the complexity, although research regarding the identification of a license plate number and the type of vehicle was done [16] In this, not only the vehicle was identified but also its specific information which includes license plate, color, vehicle model were described.

➔ Shivakumara et al. (2010) proposed an algorithm for the detection of video text for high and low contrast images, that are classified by the analysis of the edge difference between Canny and Sobel edge detectors [16]. After computation of edges and textures,, low and high contrast thresholds are used for extracting text characters/objects.

➔ Prathamesh Kulkarni et al., Automatic Number Plate Recognition (ANPR) is a real time embedded system which identifies the vehicle number automatically.[16] Here number plates were recognized based on Indian conditions(number plate standard rarely followed). It consists of integration of different algorithms under wide range of illumination conditions with a success rate of about 82%.

➔ Jing Zhang et al. (2008) had proposed a ‘new edge-based text verification approach for video in which, new edge based verification of text approach was proposed for video.

➔ Shivakumara et al. (2011) proposed a laplacian approach to multi oriented text, this method has the capability of handling texts with arbitrary orientation.[16] A Fourier Laplacian Filter is used to filter the image. Candidate region of text is identified on the basis of maximum difference using K-means clustering. Edge density and Text string straightness are used for the elimination of false positive.

➔ Palaiahnakote Shivakumara et al. (2012) proposed a multi-oriented video scene text detection through Bayesian boundary growing method and classification. [16] A new enhancement method which includes product of Sobel and Laplacian operation to enhance text pixels in a video was presented.

➔ Shivakumara et al. (2008, 2009, 2010, and 2012) proposed a method for text detection in video image and camera image based on edge features and texture features. The main focus of these methods was text detection in a video but no text detection in images of nature scene. Therefore, this method provided a good accuracy in text detection from a video.

With every technology, having its shortcomings and advantages over other technology. Image Processing Techniques was preferred as it mostly involves the software functioning and talking about the hardware part, then it can be fulfilled by the pre-existing traffic monitoring camera infrastructure; which makes Image Processing preferable over other technologies. Reasons for not using FPGAs or ARM based processors or their combinations with Digital Image Processing techniques-

• FPGA

- Uses hardware implementation thereby making it expensive. Although the FPGA costs have drastically come down with time but they still are generally more expensive than sequential processors.[13][14]

- Has **limited amount of internal storage** so need to operate on smaller data sets. For using larger data sets external memory is required which not only makes expensive but also makes it a little slower for larger data sets, the information has to be processed in the external memory and then the output is transferred internal memory which progresses towards further process.[8]

- Some FPGAs have low power modes which helps to reduce current consumption; some of these may also require external mode control ICs to fulfill this purpose. [13]

- The power consumption by FPGAs is more and programmers generally have no control over the power optimization in FPGAs. [14]

- While programming in FPGA, user needs to have the library of Verilog/VHDL programming language as well as the fundamentals digital system. [14] VHDL/Verilog programming languages are not as simple as the C++ or Matlab and they also require the knowledge of different simulation tools.

- FPGAs are mostly task specific and they need to chosen at the beginning of the task which limits it design size and features.[14] For advanced utility the programming becomes complex. On the other hand, programming in Matlab can be easily done, redesigned with less complexity and can be altered as per the requirements.

- FPGAs are designed with the primary aim of prototyping. Practical implementation on large scale requires more complex and additional circuits and memory units.

• <u>ARM</u>

- LP detection and localisation is done on the External Memory, owing to large size of data [8]

- Debugging becomes difficult.

- The NP detection algorithm is first executed using RAM. Due to the size of image (1920 x 1080) data, the performance was slow. Faster time is achieved by moving the entire image data into a memory that is external. [8]

1.2 ADVANTAGES

• Computationally Inexpensive

• Can be run in real time to recognize all standard number plates

• Improving Road Safety

• Reduces Criminal Activities

• Deterring Terrorism

• Prepaid Parking members can be easily differentiated from non members

• Better Security

• Reduced Vehicle Identification time in real time as compared to others methods

• Alarming authorities for suspected vehicles

1.3 APPLICATIONS

- Management of Parking Lot
- Border Control (Indo -Nepal)
- Tolling to reduce travel time, congestion and required man power
- Security control of military zones and government offices
- Traffic Control and Law Enforcement
- Access Control
- Identify Stolen Vehicles
- Recognize vehicle and the owner details
- Measure vehicle journey details

1.4 OBJECTIVE

The principle objective of this project is to present an efficient methodology of ANPR system for fast, effective, feasible infrastructure processing. Specific Objectives that were kept in mind for the development of the Automatic Number Plate Recognition System are mention below:

- To obtain the image of the number plate with better details by enhancing the number plate area using Image Processing Techniques.

- To obtain the number of vehicle by segmenting out the characters present in the number plate image

1.5 OUTLINE REPORT

Chapter1:- In this chapter, the basic idea of the ANPR system was introduced along with briefing of the three basic processes that are essential to obtain the vehicle number in this project. The main idea as to why this methodology is looked forward in recent past and the need to focus on this area of methodology inspite of having other methodologies is discussed.

Chapter2:- In this chapter, the three basic processes mentioned above are discussed in detail; consisting of the necessary subprocesses along with their importance. Along with the basic processes the some basic functions needed for the completion of the project are also explained.

Chapter3:- In this chapter, all the vehicles plates that were captured are presented along with the process wise output of the MATLAB functions for better understanding. The presentation of the output images along with input image that was captured, helped us in easily comparing the input and output and thereby making it easy to predict the efficiency and accuracy of the system.

CHAPTER 2
METHODOLOGY

In this this chapter, the methods for the step wise progress to obtain the number plate from the image are explained. License Plate Detection follows an Elementary technique of Templates matching.

- An input image of the number plate is fed to system using a high speed camera (number plate should be clearly visible and dominant in the image).

- Then the image is filtered. Filtering of the image is followed by exhibition of region based operations.

- After the number plate region is detection it tries to capture regions of the characters that are to be identified in a processed binary image.

- Lastly with the aid of template matching, the characters are matched against the templates stored within the data base by the user, and output string of number plate is shown in form of text.

2.1 BASIC PROCESSES

2.1.1 IMAGE ACQUISITION

The first stride to initiate the processing of ANPR starts with capturing of the Vehicle Number Plate. This process of capturing the Vehicle Image involves the usage of a high speed, high resolution, better quality camera so that the vehicle can be captured

even in different conditions and different condition which includes different lightening conditions; weather conditions including fog, rain, low visibility etc; high speed of vehicles; which requires a high speed camera hardware, apart from that this the whole project designing hardly require any expenses. This system fulfills practical implementation as well since the cameras used in traffic control systems could used to make this program very cost efficient and feasible by simply connecting the camera with the software infrastructures.

2.1.2 IMAGE PROCESSING

Image processing is a means of conversion of an image into its digital form and then performing operations on the digital image with the view of obtaining an enhanced image or extracting useful data from the image. It is very powerful technique used in today's scenario for converting an image into a form which is either analog or digital so that it can made useful in the extraction of some important and useful data. It is also referred to as a kind of signal dispensation wherein the image fed acts as the input to the system, it may be a photograph or a video frame and output obtained is an image or the characteristics associated with it. A raw image is taken as an input in this entire process, it is processed and the characteristics associated with the image or an improved modified image are given as an output.

Very often Image Processing **sys**tem includes the treating of an image as a 2D signal on which a set of methods using signal processing is applied. In today’s world it is among the rapidly growing technologies which find its application in almost every field including business, core research area within engineering and computer science disciplines and many more.

In ANPR, the method of image processing starts with the reading of the image as it is necessary for application of other functions, this read image is then resized to a

standard size and is followed by the conversion of the captured RGB/coloured image into gray scaled image. This gray scaled image undergoes the application of filters for removing the noises that appear when the image is captured. Filtered Image undergoes various morphological operations to obtain enhanced results in image. It is often found that some characters have empty spaces in between them, which are usually filled; image thinning is done to ensure character isolation,selection of region in image beyond certain area for boundingbox method; thereby completing the last step of image processing technique.

Three basic processes are mainly involved in image processing

- Image is fetched with the help of any available tool say camera.
- The image fetched undergoes analysis along with some necessary manipulations that are made on the image in order to find significant patterns in it, these patterns are generally not visible to a naked human eye.
- The output stage is the last stage where the result is either report based or an image.

2.1.3 OPTICAL CHARACTER READER

Optical Character Recognition or Optical Character Reader(OCR) is a mechanical or an electronic conversion of handwritten, printed or typed text images into machine-encoded text, either from a scene-photo, a picture of a document, a scanned document or from the subtitles superimposed on an image. Herein the process is divided into several phases to obtain the text from the image. The process starts with the Object Reduction which is followed by Segmentation of characters present in the image which is followed by the process of template matching.

This firstly involves the process of object reduction where the objects that have an area less then a threshold value of area are removed. This is mainly done to remove the irrelevant added objects in the object and to make identification of characters easy.

After the removal of the irrelevant information/object using object reduction, the characters on the number plate are segmented via the process of Segmentation. Segmentation is a very important part of the OCR and the process of OCR starts mainly with this. Object reduction is not required for images with standard number plates, but in a country like India where number plates are not standardized everywhere and customized number plates(with different fonts, characters and images) are used, Object Reduction is made necessary. Segmentation process requires the use of the edges which is why the image is converted into a gray scaled image at the starting of the whole project.

After the segmenting the characters we simply need to identify the characters. Identification of characters is done by the process of Template Matching. Template matching is done by simply comparing the segmented character with every character stored in the database and finding the correlation value in each case. The case with the highest correlation value is given as the character output value.

Although Optical Character Reader is the last step, yet is also the most important step for the completion of the project as a small error in any sub `sequence of OCR might result in the failure of obtaining the correct output.

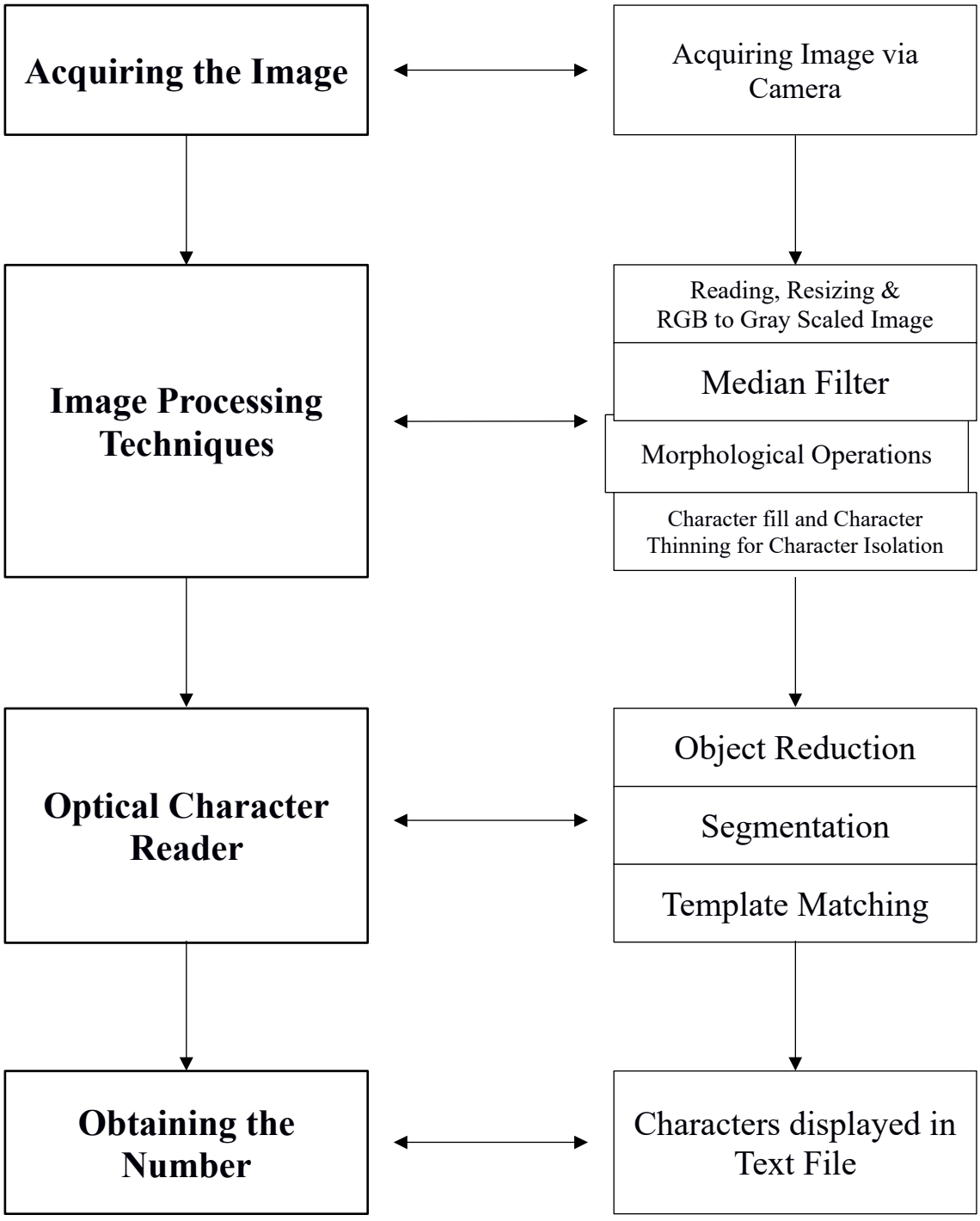


Fig2.1: License Plate Identification Process Flowchart

2.2 ACQUIRING THE IMAGE

The first and foremost step to initiate the process of Vehicle Number Plate Detection is acquiring the image. The image could be either captured with the help of high speed camera or uploaded from any device. Most often image is acquired using a high speed camera which captures the fast moving vehicles. The cameras generally have fast shutter speed with high resolution and better pixel capturing capability which can capture pictures under different weather conditions like rain, fog, low visibility and different lightening conditions including dark and bright. These cameras also possess large zoom ranges with wide angle zoom options without deteriorating the pixels of the image. Most commonly the system uses infrared lighting in order to acquire images by allowing the camera to take pictures of the vehicle at any time of day or night. [15] The image used in the project could also be of jpg, png, jpeg format, or any other image format; Image shown in the project are either taken from research papers/journals ,image captured from a phone camera or professional camera is also used to show some of the processes. Mobile phone cameras can be used for research work if the high speed camera is not available so as to minimize the cost of the project and make it cost efficient. Care must be taken regarding the quality of image as using low quality cameras/devices could produce images that might contain poor pixels/degraded pixels along with low resolution of image that increases the chances of error thereby producing invalid/unexpected outcomes.

Implementation of the project on real grounds mainly requires the high speed camera hardware. Practically considering the implementation of the project, the pre- existing surveillance infrastructure used in monitoring of the traffic vehicles could be used to minimize the cost. All we need to do is to connect the camera infrastructure with the software unit that runs the scan to identify the plate. This implementation helps us in not only making this project practically feasible but also making it cost efficient with the upgraded software unit.

The main task in acquiring the image is done by the camera unit, the camera system takes images of each vehicle passing by and then forwarding the image to the computer system which processes the license plate of the vehicle by the use of Automatic Number Plate Recognition Software

The images used in this project have been taken from different research papers and journals for easy stimulation of the results.

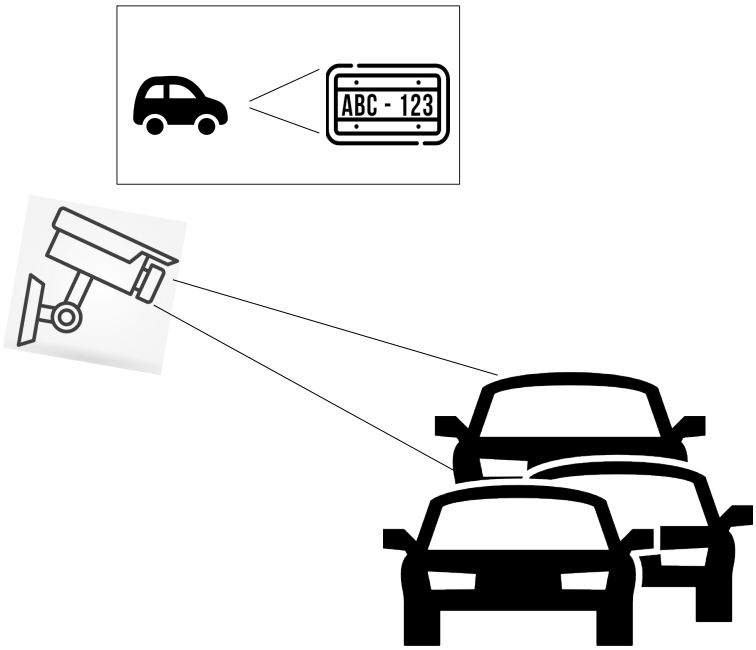


Fig22. : Image of the vehicle whose number is to be identified is captured using a high speed camera

Fig2.3: Image aquired via Mobile Camera

2.3 IMAGE PROCESSING TECHNIQUES

Image Processing Techniques consists of a combination of different methodologies which are essential to obtain an output image which is more enhanced in comparison to the original input image. This output image makes the details in the image clearly visible and identifiable , which are easily understandable by the ANPR System for the extraction of the details present in the image.

These processing Techniques are applied to the input image to obtain output image as desired by the user(User here refers to the ANPR System and sequence of these methodologies is designed after analyzing different possibility of results).

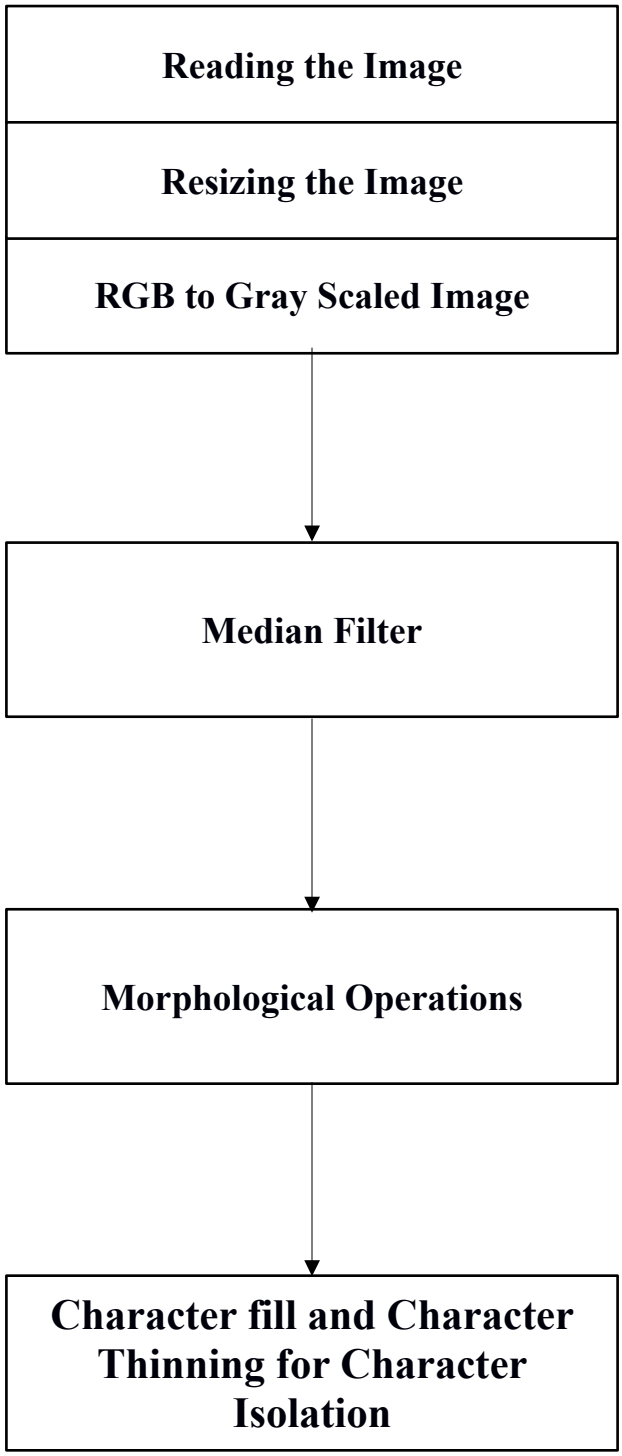


Fig2.4: Image Processing Techniques Flowchart

2.3.1 READING, RESIZING AND RGB TO GRAY SCALED IMAGE

- The first and the foremost step to start the process of Vehicle Number Identification is **reading the image**. To extract the characters/text from the image, we need to first obtain and read the source image. The image is read by accessing the filename of the image from a particular file.

Reading in MATLAB

f= imread('carplate2.jpg') ;

- We need a standardize the size of the image for fast and efficient processing of output and to do so we **resize the image** after reading it. Resizing also helps in minimizing unexpected error, occurring either due to the small size of the image which might contain some damaged/missing pixels or large size of the image which increasing the processing time or may even result in a processing error.

Resizing in MATLAB

*f=imresize(f,[400 NaN])**;***

Image file with filename f is resized to have 400 rows. imresize automatically calculates the number of columns.

- 

Fig2.5: Reading and resizing the image

- The resized RGB/coloured image is converted into **gray scale image**. Since to identify the image characters in the LP we need to detect the edges of the characters present in it, which can only be observed by making the edges visible. This can be done done converting the coloured image into a gray scaled image where different intensity levels help in easy detection of edges.

RGB/coloured Image to Gray Scale Image in MATLAB

g=rgb2gray(f);

Converts true colour of RGB image file with filename f into gray scale by the elimination of saturation and hue information and assuring that the luminance is retained.

Fig2.6: RGB /Coloured Image to Gray Scale Image

2.3.2 MEDIAN FILTER

Impulsive Noise- Impulsive Noises as the name suggests refers to the impulsive/short duration noises which degrade an image. These noises occur during the acquisition of the image due to sensor temperature, interference in the channel or atmospheric disturbances due to transmission. This noise is also known as **Spike Noise** or **Salt and Pepper Noise**.

The PDF of Impulsive Noise/Salt and Pepper noise is given as-

$$p(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases}$$

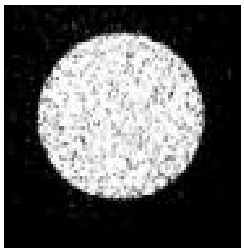


Fig2.7: Salt and Pepper/Impulsive Noise

In the above mentioned mathematical interpretation of Impulsive Noise, if b > a, intensity b will be appearing as a light dot in the image. On the contrary level a will be resembling a dark dot. The impulsive noise is called unipolar, if either of P_a or P_b is 0. Impulse noise values resemble the granules of salt and pepper which are randomly distributed over the image if none of the probability is zero, especially if they are approximately equal. Because of this, bipolar impulsive noise also is called salt and pepper noise. Spike noise and Date drop out are also some of the terms used to refer to this type of noise. [6]

Fig2.8: Vehicle Number Plate with Impulsive Noise

This Noise can be eliminated using Median filter. **Median Filters** are best known to remove Impulsive/Salt and Pepper Noise

Median Filter- A non linear method which is used to remove noise from pixel, images, or over the entire image is referred to as Median Filtering. By simply sorting all the existing pixel values at first, from the window into a numerical order; and then replacing those pixels being considered with a middle (median) pixel value, the median is calculated.

- Definition
  - The middle value of an ordered list.
  - If there is no middle value, average of the two middle values.
- Mathematical Representation

  $$\mathbf{Y_n = median_{m=0,M-1}\ \{X_{n-m}\}}$$
- Advantages
  - Good edge preserving properties
  - Preserves sharp discontinuities of significant length
  - Eliminates outliers, without blurring the signal
- Applications
  - The most effective algorithm to remove sudden impulse noise
  - removes outliers when smoothing a pitch contour

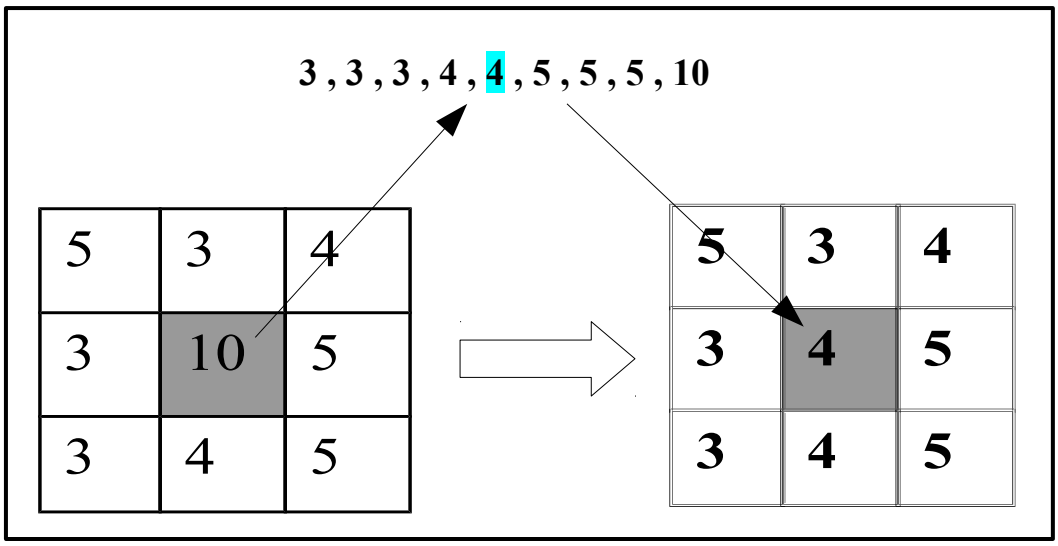


Fig2.9: Median Filter used in 2d image(all the values of matrix are arranged in accending order and the median is found, central value is then replaced with median)

MEDIAN FILTER ALGORITHM

We start with 1d for better understanding of how the median filter works.

- Let's assume the array mentioned below:
  A = [3 2 1 6 5];
  Also an assumption is taken regarding defining the window size of n = 3.

  - Placing ourselves in the first array component, i.e. 3. Having a window size of 3, we take that number of samples, keeping in mind that a sample appears to the left and the other sample to its right. Since it is the first value, and there is hardly any sample to the left, so we assume a zero:
    0 3 2

- Starting from this window, we start sorting values of the selected components from minimum to maximum and obtain the median i.e. the value in the middle.
  0 2 3

- Now the middle value is replaced with 2. This value is now written in the filtered array A.
  A = [2 2 1 6 5];

- After this we proceed towards the next value of a, i.e. 2. The sample to the left (that has been already modified) and the right side sample are considered now
  2 2 1

  - This sample group is sorted and median value is found (in this case median comes out to be 2 again)
    1 2 2

  - The filtered vector A now becomes
    A = [2 2 1 6 5];

- This continues till all the array components are dealt with in the same manner. At the end, we obtain a filtered vector A
  A = [2 2 2 5 5];

- A median filter in any image, be it Black and white, Gray Scaled Image or RGB/Coloured Image, works in a similar manner, except the fact that it works in 2d. In that case we not only take the pixel values that are to the left or right, but we take all the values which are surrounding the sample pixel we are in. After the all the values are arranged in an ascending order following which the middle value is found. The center pixel surrounded by all other pixels is then replaced with the

median that has been found by taking all these neighbouring pixels including the center pixel.

(i) (ii)

Fig2.10: Effect of Median Filter on Salt and Pepper Noise
(i): Image with Salt and Pepper or Impulsive Noise
(ii): Median Filter used to remove Salt and Pepper or Impulsive Noise

Median Filter in MATLAB

g=medfilt2(g,[3 3]);

This function performs median filtering, in an **m x n** matrix, the pixel containing the output consists of the median value of the neighbouring pixels corresponding to the input image.

2.3.3 MORPHOLOGICAL OPERATIONS

STRUCTURING ELEMENT- A structuring element represents a matrix which is used to identify the pixel in the image which is being processed. It also defines the

neighbourhood of the pixels in the matrix which is used in the processing of each pixel. Structuring element is an important role in dilation, erosion, opening, closing and other morphological operations. Structuring element can be of various sizes and shapes including sphere, diamond, disk, rectangle etc.

For almost every basic morphological process, the concept of structuring element is required, Structuring element is chosen as per the user requirements which includes the number of neighbourhood pixels that are to be considered , for the particular morphological operation to be implemented, around the centralized or main pixel. The complex morphological operations with the help of the structuring element can help in enhancing the image but the wrong choice of the structuring elements can even lead to the loss of information in some cases which tells us that the structuring element highly important for the application of particular morphological operation.

Hence care must be taken when the choice of structuring element for the a particular morphological operation is done.

Structuring Element in MATLAB

struc = strel('disk', 15)

Strel is used to represent a flat morphological structuring element. This is an essential part for morphological operations like dilation and erosion. A structuring element in a disk shape is created with a radius of 15.

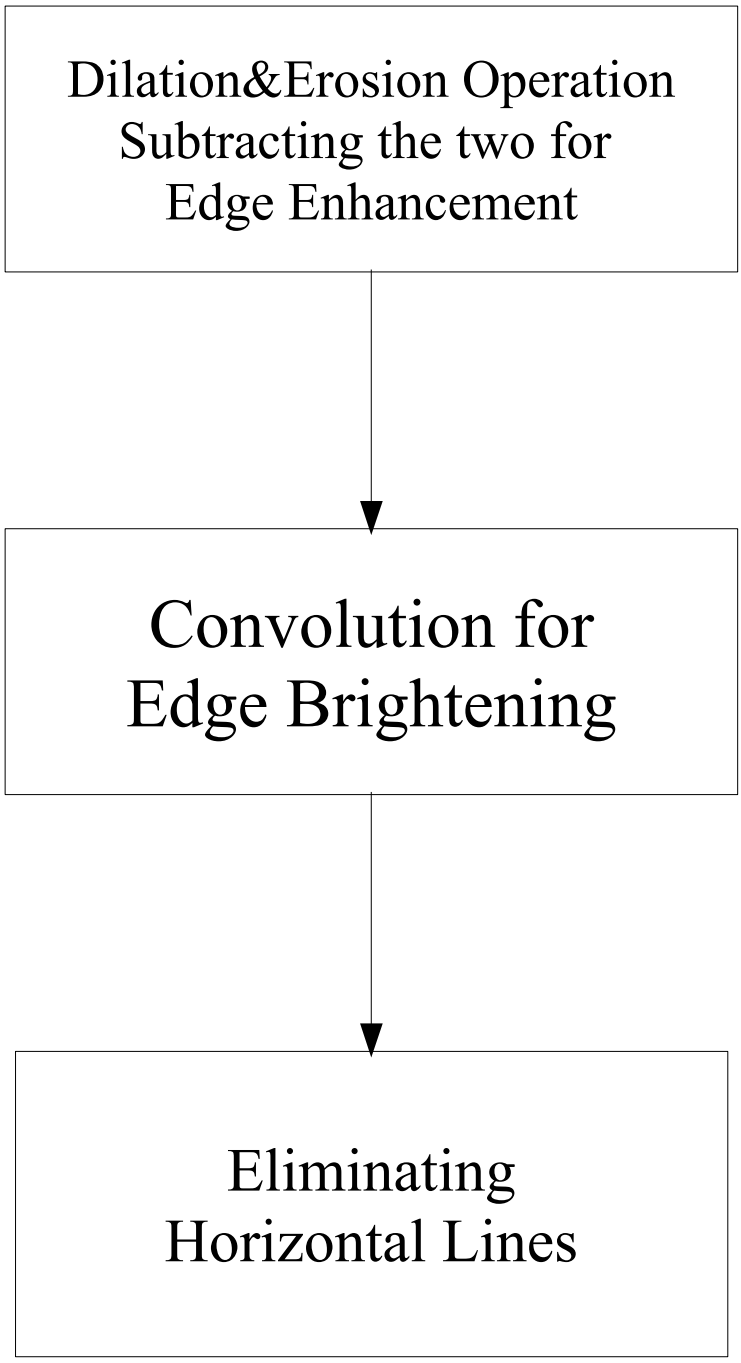


Fig2.11: Morphological processing sequence Flowchart

(1) **DILATION&EROSION OPERATION SUBTRACTING THE TWO FOR EDGE ENHANCEMENT**

➔ **DILATION FUNCTION**

- Dilation is the fundamental morphological operation used to thicken objects in binary image using structuring element.

- It is represented by $\oplus$.

- Dilation adds pixels to the boundaries of object.

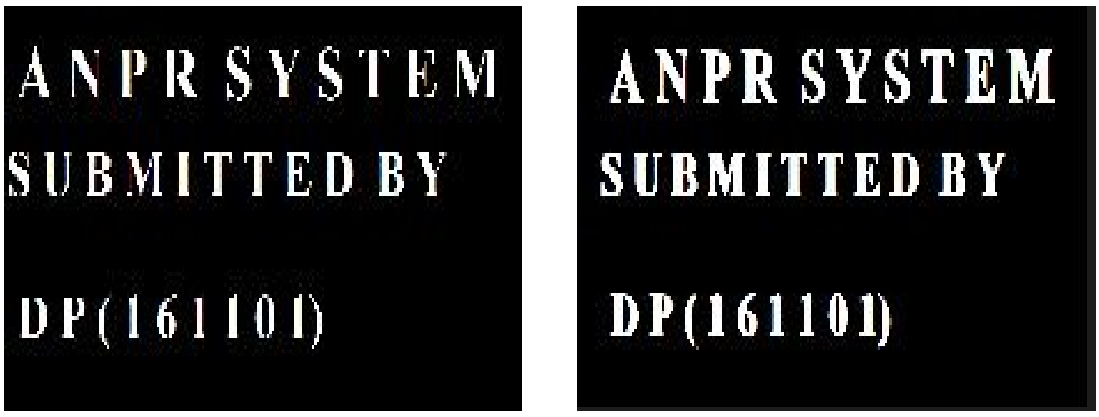
  - Mathematical Representation

$$A \oplus B = \{ Z \mid (\hat{B})_Z \cap A \neq \Phi \}$$

$$A \oplus B = \{ z \mid [(\hat{B})_z \cap A] \subseteq A \}$$

(i) (ii)

Fig2.12: Dilation of an object using structuring element
(i) Reference/Standard Figure containing text
(ii) Dilation of text in reference figure using Dilation Function



(i) (ii)

Fig2.13: Dilation of an object using structuring element
(i) Reference/Standard Figure containing text
(ii) Dilation of text in reference figure using Dilation Function

Dilation in MATLAB

I= imdilate(image, se)

Returns the dilated image i, where structuring element se is used.

➔EROSION FUNCTION

- Erosion is the fundamental morphological operation used to shrink objects in binary image using structuring element.

- It is represented by $\ominus$.

- Erosion removes pixels on object boundaries.

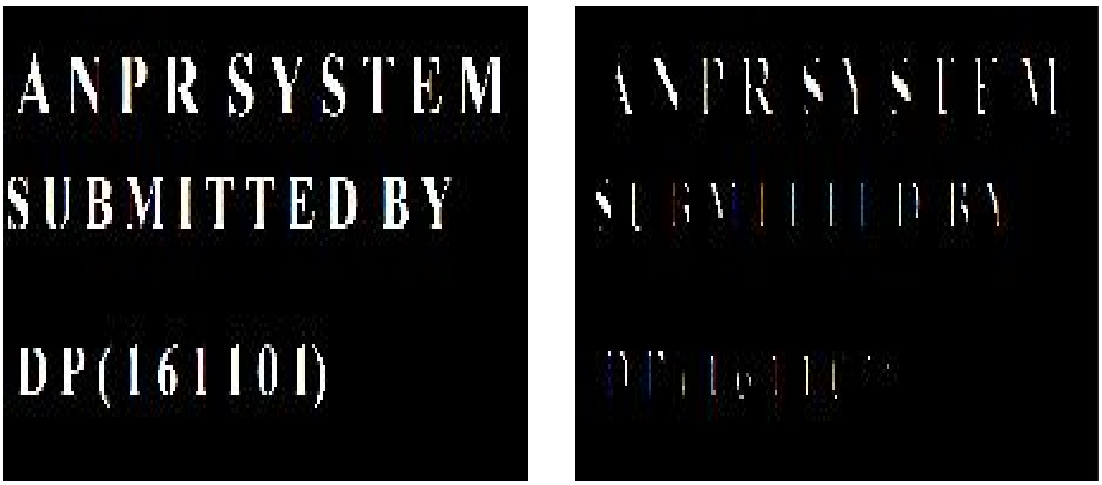
  - Mathematical Representation

    $A \ominus B = \{ z \mid (B)_z \cap A^c \neq \phi \}$

$$A \ominus B = \{ z \mid (B)_z \subseteq A \}$$

(i) (ii)

Fig2.14: Erosion of an object using structuring element
(i) Reference/Standard Figure containing text
(ii) Erosion of text in reference figure using Erosion Function



(i) (ii)

Fig2.15: Erosion of an object using structuring element
(i) Reference/Standard Figure containing text
(ii) Erosion of text in reference figure using Erosion Function

Erosion in MATLAB

I= imerode(image, se)

Returns the eroded image i, where structuring element se is used.

➔ The dilated and the eroded image are subtracted in order to obtain an output with enhanced edges. Morphological gradient is obtained by subtracting the dilated and eroded image which refers to an image in which contrast intensity of the neighbouring pixels of a particular pixel is indicated by each pixel value. It is very beneficial for Segmentation and Edge Detection.

(2) CONVOLUTION FOR EDGE BRIGHTENING

Convolution refers to a mathematical operation performed on two functions(f&g), producing another function which expresses how the shape of one function is modified by the another function. It can also be referred as an integral which expresses the amount of overlap of one function as it is shifted over another function. Convolution is generally applied to an image in order to apply effects such as blurring, sharpening, outlining or embossing the image. The application of the particular function depends upon the type of kernal(a small matrix used to apply different effects) used in the convolution process.

Convolution in MATLAB

img=conv(img, kernal)

(i) (ii)

Fig2.16: Convolution (Brightening)
(i) Original Image
(ii) Brightned Image using convolution

(3) ELIMINATING HORIZONTAL LINES

The logical image and the eroded image are subtracted in order to obtain an image with eliminated horizontal lines. These horizontal lines are mostly the edges of the number plate present in the region grow.

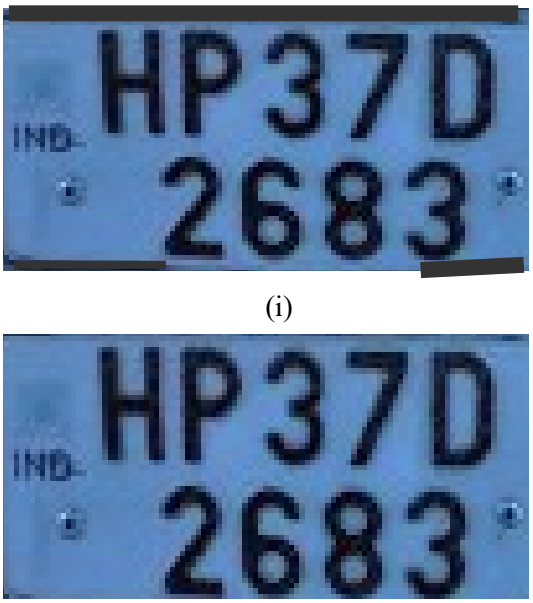
MATLAB

L = logical(a)

A is converted into an array of logical values. This is done to obtain the binary image class from double.

er=imerode(B, strel('line',100,0));

Erodes the image with structural function as a line that is symmetrical in comparison to neighbourhood center, and has length approximately 100 and angle as 0 degree.



(i)

(i)

Fig2.17 : Elimination of horizontal linesat the edges of number plate
(i) Number Plate with horizontal edges
(ii) Removal of horizontal lines

(i) (ii) (iii)

Fig2.18: Elimination of possible horizontal lines, via erosion function using line structuring element, from the output image of regiongrow that could possibly be the horizontal edges(borders) of the license plate.

(i) License Plate Image with Horizontal Lines and irrelevant objects
(ii) Erosion function to remove horizontal border lines through line structuring element
(iii) Removal of the existing horizontal lines/horizontal borders of the License Plate

2.3.4 CHARACTER FILL& CHARACTER THINNING FOR CHARACTER ISOLATION

After the removal of the horizontal lines, the gap in characters are to be filled and thinning is required to be done so as to easily isolate them for further processing. Adding to this the small elements in the background also need to be eliminated via erosion function.

➔ **CHARACTER FILLING**

Most often it has been found that some of the characters tend to have empty spaces in between them as per the standard calligraphy. The templates stored in the database do not contain any empty space to avoid any chance of error. In most of the experiments it was found that characters such 8 & B could be easily differentiated with better success rates, when they filled; rather then when they were not filled, chances of error or the system getting confused between the two increased. Therefore character filling is made as a compulsory step to minimize chance of error and increase the system's efficiency.

Character Filling in MATLAB

I= imfill(i,'holes')

The holes present in the input binary image, i are filled. Here, a hole represents a background pixels set which cannot be reached by background filling from the image edge.

➔ **CHARACTER THINNING**

Characters need to be isolated for increased efficiency of Optical Character Reader because characters being far could be easily differentiated in OCR process. The characters are isolated by thinning them so as to reduce the connected strokes between

them. After this the image is eroded so as to remove the pixels from the area where characters tend to meet. This is done to ensure minimization of error by making the process of object reduction and segmentation easy.

Character Isolation in MATLAB

I = bwmorph(image, operation, n)

The operation is applied n times. Mostly n is inf here, in this case, this operation repeats itself until the image can be no longer changed.

Operation-*thin*

Objects are thinned to lines. It is used to remove pixels in order to shrink the object without holes to minimally connected strokes, and moreover an object containing holes is shrunk into a connected ring halfway between each hole and the outer boundary.

H=imerode(H, strel('line',3,90));

Erosion is done to ensure that the very small elements in the background are eliminated so as to make the characters clearly visible and remove background elements.

(i) (ii)

Fig2.19: Character Filling, Character Thinning and Erosion is performed

(i) License Plate Image with gaps in the characters, thick characters that are joined via small strokes and small background elements
(ii)License Plate with filled gaps in characters, thinning of characters to ensure reduced connected strokes between them for better character isolation and removed small background elements

2.4 OPTICAL CHARACTER READER

Optical Character Recognition or Optical Character Reader(OCR) is a mechanical or an electronic conversion of printed text, handwritten or typed images into machine-encoded text, either from picture of a document, a scanned document, from the subtitles superimposed on an image or a scene-photo. Optical Character Reader consists of sequential processes which starts with the Object Reduction, followed by Segmentation of characters present in the image and finally the process of template matching.

2.4.1 OBJECT REDUCTION

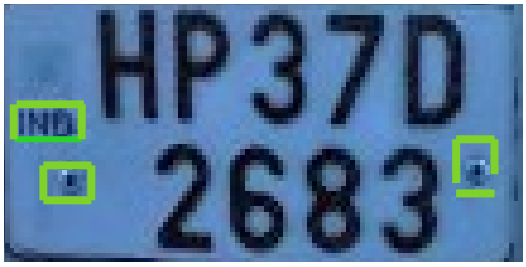
Object Reduction is done remove the useless object/fonts added to the number plate or in simple words it is used to remove the irrelevant added objects from the number plate. The need of Object Reduction was felt after the realization that in spite the number plates are standardized all over the country, they are not made compulsory and moreover the delay in providing standardized number plates to the vehicles by the Government increased the need of this function; non-standardized number plates mostly consist of customized fonts, texts and designs which need to be eliminated for efficiently recognizing the vehicle number. This is done by simply removing the objects that have an area less than a threshold area.

Object Reduction in MATLAB

Imag = bwareaopen(i, p)

Removes all connected components (objects) that have fewer than p pixels from the binary image i, producing another binary image, Imag. This operation is known as an area opening.

- Opening function is generally generally used for smoothing the contours of an object, to break narrow isthmuses and to eliminate thin protrusions.



(i)

(ii)

Fig2.20 : Object Reduction
(i) NP with irrelevant objects
(ii) Reduction of irrelevant objects

(i) (ii)

Fig2.21: Object Reduction is done to remove the irrelevant regions/objects from image

(i) Regions having pixels more than certain value are selected for bounding box
(ii) Regions having area less than certain threshold value removed to eliminate irrelevant objects

2.4.2 SEGMENTATION

The number plate is divided into multiple number of sub images where every sub image has at least one character in it. Segmentation is done so that all the characters are uniquely differentiable and easily identifiable during the process of Template Matching.

For the segmentation process to be efficiently executed, the characters are thinned. Every step is inter- related to one another. This is done with the help of two basic functions -

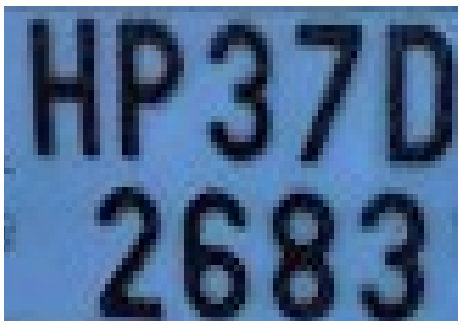
(a) Conn Function that adjusts the length of the object and
(b) Takethis Functions that sorts the objects with same length.

- The process of segmentation involves the application of bounding box where the region consisting of number plate is boxed and the characters are segmented.

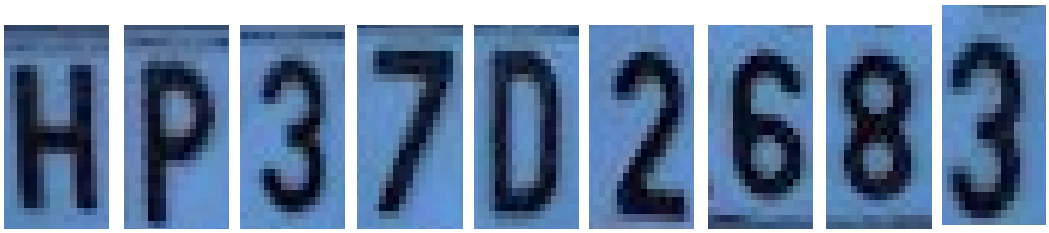
- Vertical boundaries of each digital character is found.

- Each character is resized into the size same as that of the template stored in the database.

  - *Conn function*- it takes the data, checks the length and shorts same kind of objects; this makes use of another function that is takeboxes function. Takethisfunction is used to check the length of the objects and sort out the objects that have same length.



(i)



(ii)

Fig2.22 : Character Segmentation
(i) NP Image after Object Reduction
(ii) Segmentation of Number Plate Characters

(i)

(ii)

Fig2.23: Segmentation of Characters after the reduction of irrelevant objects
(i) Characters only visible after the object reduction
(ii)The segmentation of characters present in the number plate image

2.4.3 TEMPLATE MATCHING

The process of template matching plays paramount role in the last stages. It compares each character obtained from the process of segmentation and matches each of that character with the stored templates in the database. After all templates stored in the database are matched with the particular character, the template with the best match is given as the output. Template Matching uses the idea of correlation coefficient where the comparison with highest value of correlation coefficient is given as output.

- Each character is matched with the every template stored in database and correlation coefficient for each match is given.

- The template with highest correlation coefficient is shown as the result.

The used templates are given in the figure below:

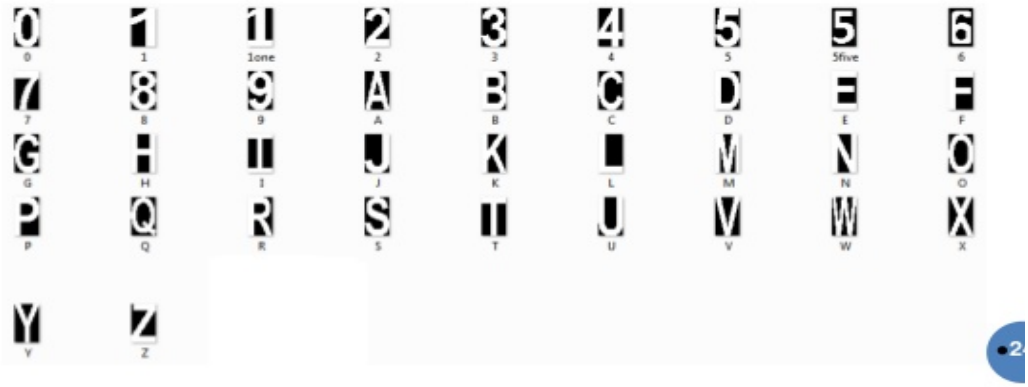


Fig2.24 : List of templates stored in data base

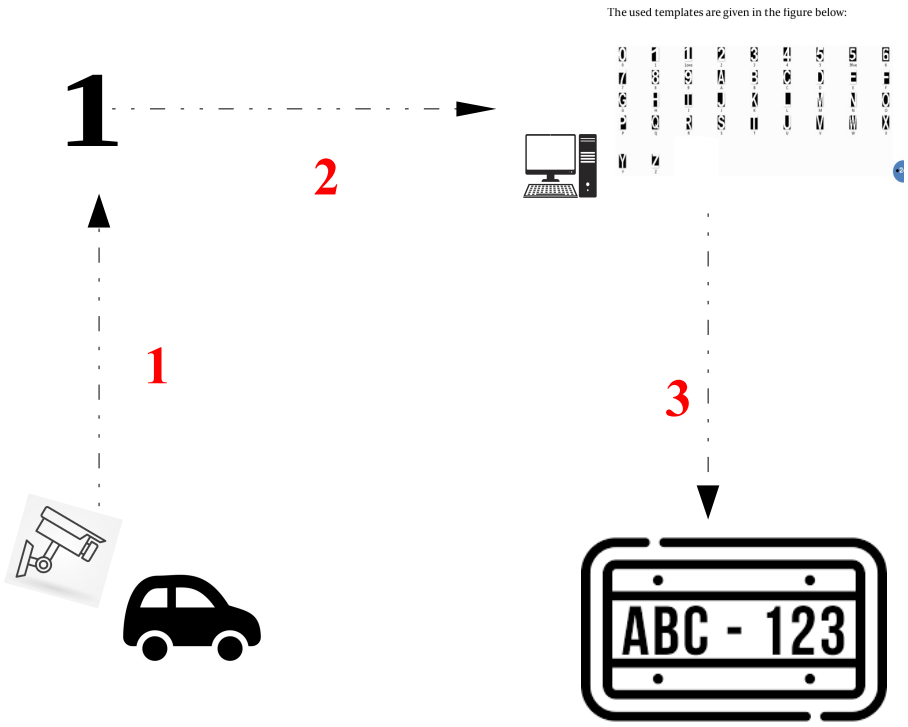


Fig2.25: Template matching to obtain the vehicle number
1. The segmented characters of number plate image are obtained
2. Each character is compared against every template stored in data base,
correlation coefficient corresponding to each comparison is recorded
3.The template with highest correlation coefficent is given as output

2.5 OBTAINING THE NUMBER

After the Template matching, the number plate characters are identified and displayed in a text file. Number of the vehicle is obtained and displayed in the text file which signifies the completion of the procedure for identification of the number plate. The experimental results verify that system presented here successfully managed to detect and recognize the vehicle number from it number plate image on real images.

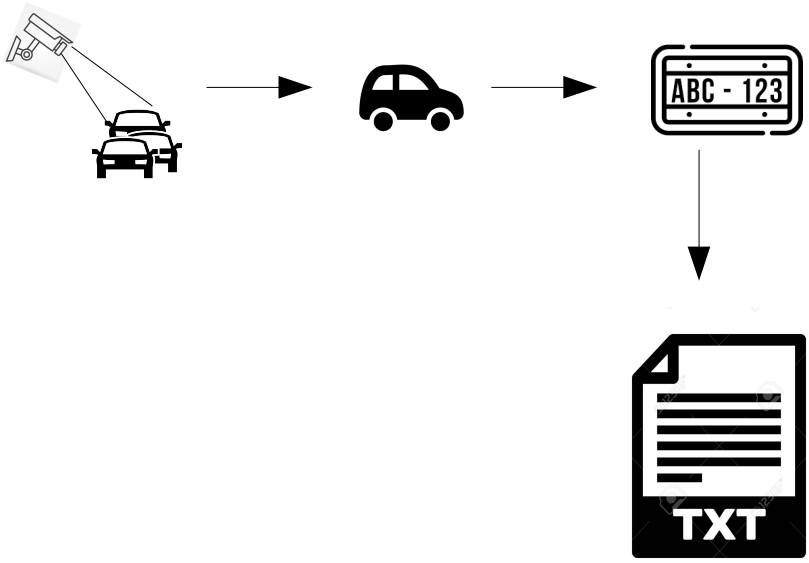


Fig226. : Number of vehicle obtained in Text File
The Car Image is aquired froma natural scenario.
After application of Image Processing and OCR,
The vehicle number is displayed in text file

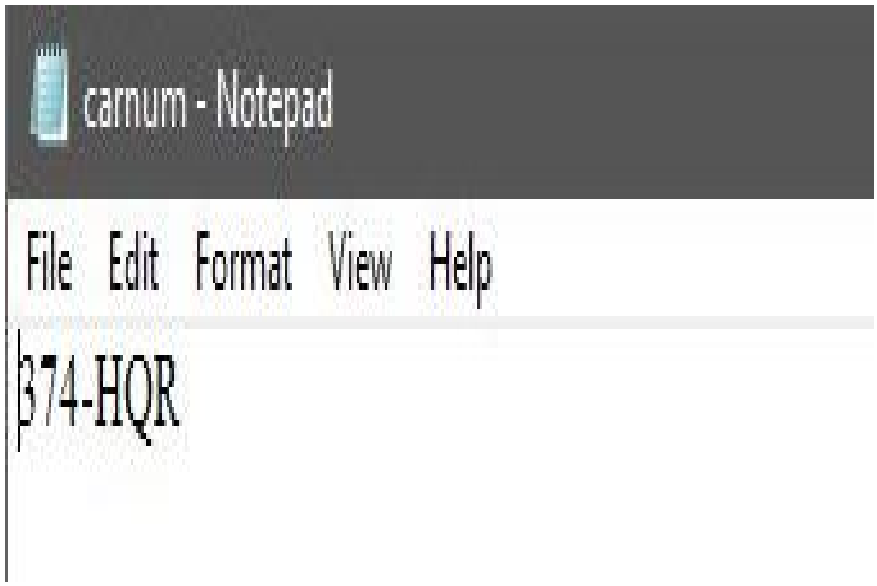


Fig2.27: Vehicle Number displayed in text file

CHAPTER 3
RESULTS

In this Chapter, the outputs of different input images is shown in a sequential order. The sequence follows the same format of the processing as it is done to identify the number plate. Here each figure number represents a particular process. Each process appears as an output during the execution of the program has been explained along the image results. Process is presented in a combination of seven images, and these seven images represent seven essential steps that are executed with the help of images as output. These steps have been explained with each sub part of image representing a standard step.

The representation of the process by the standard step number with the help of respective figure number is as follows :

i. **Reading and resizing the image**

ii. RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output

iii. **Eroded Image for eliminating Horizontal Lines**

iv. **Character Filling, Character Thinning and Image Erosion to remove small elements**

v. Object Reduction

vi. Segmentation

vii. Vehicle Number Displayed in Text File

Each process is sequentially explained with the help of the output images in a brief manner to get an idea about how the program actually functions to extract the characters of the number plate through a vehicle plate image.

Program makes use of various functions for making the main program look less complex and function efficiently. Various functions such as Boundingbox, OCR methods etc have been taken directly from the internet due to the complexity levels owing to different scenarios, focusing more on the main programming. The function codes are standard and available in the online sources.

Four different input samples were taken from various journals and research papers to verify the proper working of the ANPR System designed which helped in accessing the success rates as well as the problems that could be faced if the minimum image requirements were not met. Moreover the flaws that were detected in the system could used analyzed as a part of future developed to enhance this project.

The sequential order of the outputs , mentioned above, as per the program designed has been shown below for the four different input sample of License Plate of vehicles belonging to different countries; which also helped in knowing about of the ANPR system's capability in being practically applicable in various other countries.

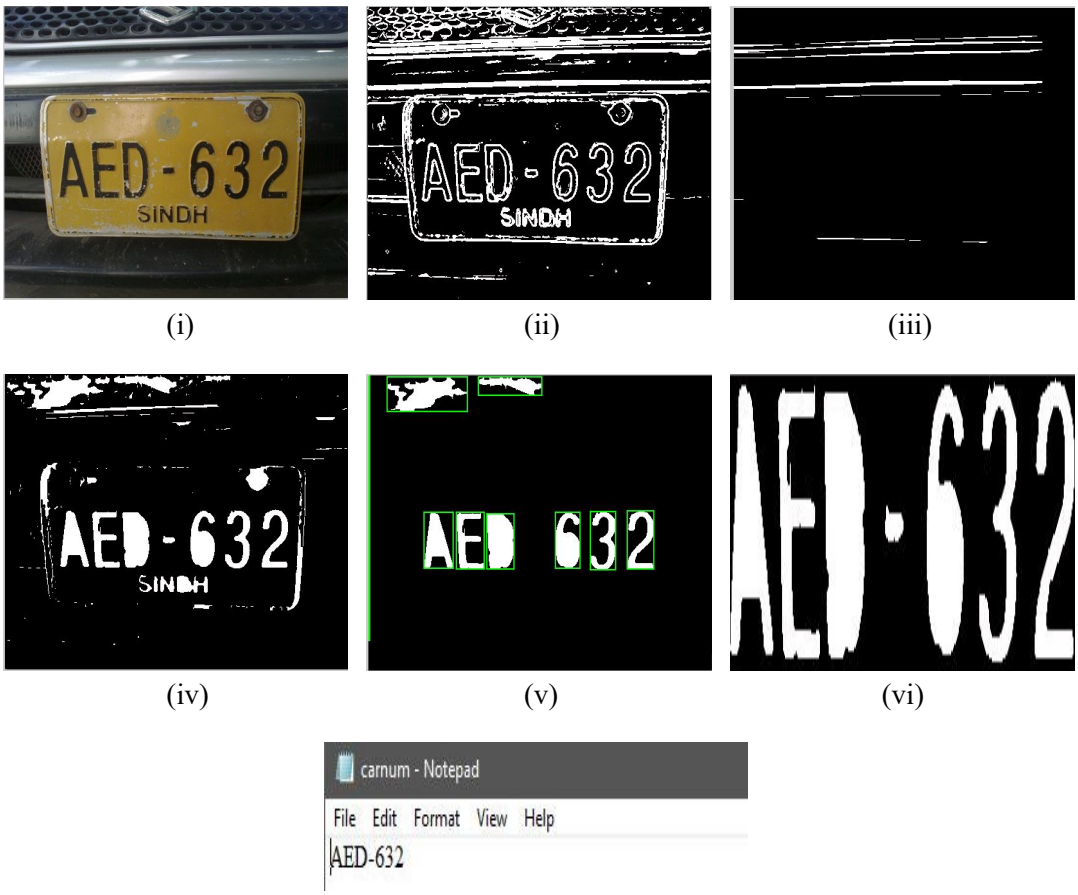
(i) (ii) (iii)

(iv) (v) (vi)

(vii)

Fig3.1: Sequential outputs of 1st Image

(i): Reading and resizing the image
(ii): RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
(iii): Eroded Image for eliminating Horizontal Lines
(iv): Character Filling, Character Thinning and Image Erosion to remove small elements
(v): Object Reduction
(vi): Segmentation
(vii): Vehicle Number Displayed in Text File



(i) (ii) (iii)

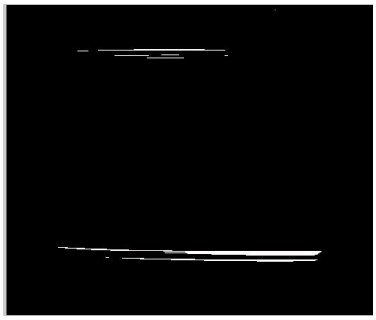
(iv) (v) (vi)

(vii)

Fig3.2: Sequential outputs of 2nd Image
(i) Reading and resizing the image
(ii) RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
(iii) Eroded Image for eliminating Horizontal Lines
(iv) Character Filling, Character Thinning and Image Erosion to remove small elements
(v) Object Reduction
(vi) Segmentation
(vii) Vehicle Number Displayed in Text

(i)

(ii)

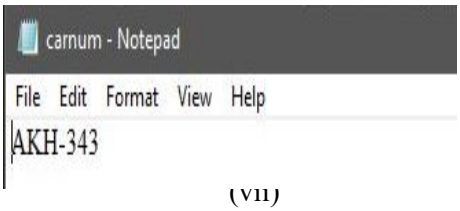


(iii)

(iv)

(v)

(vi)



(vii)

Fig3.3: Sequential outputs of 3rd Image

(i) Reading and resizing the image
(ii) RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
(iii) Eroded Image for eliminating Horizontal Lines
(iv) Character Filling, Character Thinning and Image Erosion to remove small elements
(v) Object Reduction
(vi) Segmentation
(vii) Vehicle Number Displayed in Text File

Fig3.4: Sequential outputs of 4th Image

(i) Reading and resizing the image
(ii) RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output
(iii) Eroded Image for eliminating Horizontal Lines
(iv) Character Filling, Character Thinning and Image Erosion to remove small elements
(v) Object Reduction
(vi) Segmentation
(vii) Vehicle Number Displayed in Text File

Every process has been explained in a detailed manner. For better understanding, the purpose of following each step in a sequential manner is described briefly under the step-wise labelings mentioned below.

SEQUENTIAL STEP EXPLANATION WITH PURPOSE

(i)Reading and resizing the image

The process of ANPR starts with the reading of the image. The input image is simply read by the use of command. This is first step to work of any image, care must be made regarding the image formats. Formats which include jpg, jpeg, png are only preferred and web based images are avoided.

Purpose:

This is essential for the system know about the input image which contains the vehicle whose number plate is to be analyzed.

It is then resized to a standard size. Resizing is done in every input image as a part of standardization.

Purpose:

Resizing not only makes the processing easy but also increases the success rates of extracting the number of the vehicle correctly i.e. it results in better accuracy of the system. This is carried out in every input image so that the image on which further processes are carried out has a standard size.

(ii) RGB to Gray Scaled Image, Median filter, Subtracting the Dilated & Eroded Image outputs for Edge Enhancement, Convolution and then producing Logical Image as output

The resizing of the image is followed by the the conversion of coloured image into a gray scale image. Coloured/RGB Images are a cobination of three matrices whereas Gray Scaled Image is represented through a single matrix which makes it less complex for the processing part.

Purpose:

Gray Scale Image helps in the better detection of the edges since edges are needed for differentiating different characters.

Median Filter is applied to the gray scaled image.

Purpose:

This is one of the crucial steps as care has to be taken regarding the pixels not being lost here. To remove the noise from the image pixels, mostly Salt and Pepper/Impulsive Noise that mainly occurs at the time of image capturing.

After this dilation and erosion operations are applied independently, the outputs of which are then subtracted.

Purpose:

Dilation is applied to add pixels at the object boundaries where they are missing or lost, mostly done to recover the lost pixels of an object in order complete the object boundaries.

Erosion is applied to remove pixels from object boundaries where they are irrelevant, mostly done to shrink or remove the irrelevant part of objects from an image.

Dilation and erosion outputs are subtracted to obtain an output image which has better enhanced edges since for detecting the characters we need to have an idea about its edges

Convolution of image for better and enhanced image is done and Logical Image is produced to obtain Binarized image.

Purpose:

Convolution is done for brightening the image since image obtained from the camera could be captured during a night time or under poor lightening conditions. This helps in reducing chances of error that might arise due to bad lighting conditions while capturing.

Logical Image is produced to obtain the binarized image.

(iii) Eroded Image for eliminating Horizontal Lines

Eroded Image is produced with the help of such a structuring element such that the image results in horizontal lines that represent the edges/borders of the number plate in particular. This eroded image is then subtracted from the image containing objects with horizontal lines

Purpose:

Horizontal line are displayed with the help of erosion function so as to identify the edges/borders of number plate.

Subtraction of eroded image obtained above, from image that is containing horizontal lines. Here a simple subtraction of images is done to remove the characters of that particular dimension.

Purpose:

This is done so as to remove the horizontal lines for making sure that the ROI which the number plate area is clearly visible for easy visibility of the characters present in the image.

(iv) Character Filling, Character Thinning and Image Erosion to remove small elements

The gaps in the Characters are filled. Letters having empty spacing enclosed within them are the subject of this step and they include A, B, D, O, P, Q, R, 4, 6, 8, 9, 0 as templates stored in database have no gaps.

Purpose:

Character filling is done to fill characters that have gaps so that the template matching could be made easy as the templates that are stored in the data are limited in their fonts and have all their gaps filled

Characters are then thinned.

Purpose:

This is done to reduce the characters spacing in the image, if any. Thinning helps in the character isolation as the spacing is reduced. This makes the characters easily and uniquely identifiable by the system, which is necessary in the segmentation process.

Erosion function is applied in the image after the application of above functions. Due to the present of small elements present in the image.

Purpose:

To remove the small elements present in the image background, erosion function is used with such a structuring element that helps to accomplish the motive. Presence of these elements make the characters unclear.

(v): Object Reduction

Small objects or customized objects/fonts, mainly added for making number plate look eye catching, that are irrelevant are removed. This is a necessary step whenever we enter into the process of OCR.

Purpose:

As customized objects and fonts are usually present in the number plate to make plate eye catching, we need to first remove them by the process of Object reduction via Boundingbox function. In Object Reduction, the object in the image that have an area less than the threshold/mentioned area are removed.

(vi): Segmentation

The characters are segmented in to unique characters. Segmentations refers to separation of the characters. Segmentation is the first and foremost step that should be focused upon whenever we are dealing with OCR.

Purpose:

The remaining objects/characters in the image are segmented. Each remaining object/character in the number plate is segmented into individual objects/characters. This is referred as one of the most crucial step of Optical Character Reader. As the outcome of this step decided whether the characters will be successfully obtained after matching process is completed.

(vii): Vehicle Number Displayed in Text File

The segmented characters after identification are displayed in a text file for easy view. This step is executed for proper presentation of the number and for the ease of the

Purpose:

The Characters are compared using Template Matching and the number is displayed in a text file. Lastly the outputs of all the objects/characters present in the number plate are shown in a text similar the sequence of characters as present in the number of the vehicle.

CHAPTER 4
CONCLUSION

- The Automatic Number Plate Recognition System with the use of vehicle license plate is shown wherein algorithm for vehicle number plate extraction, character segmentation and recognition is shown.

- Project implementation is fully based on software processing by the use of Image processing techniques as it is cost efficient and practically applicable

- The whole process begins with the capturing of the image via mobile camera/high speed cameras used in traffic monitoring.

- The system makes use of image processing techniques for enhancement of the captured image in order to remove all the noises and obtain an output image on which the OCR can work efficiently.

- The identification of vehicles NP is done via OCR; wherein finally by matching the characters with the templates stored in the database of the PCs, identification process is carried out.

- Probability of detection and Identification of vehicle license plate can also be defined using the statistical analysis and this can be even used to find out the efficiency of the system.

Although the implementation works pretty well however a room for making improvements still exists.

4.1 FUTURE SCOPE FOR IMPROVEMENTS

As there is always a room for improvement-

- The system recognizes and detects the vehicle robustly using LP against different climatic and lightening conditions.

- The characters can be identified wrongly because of there similar appearance. e.g. – 2 & Z, U & V, 0 & O. Different fonts of the templates for each character must be stored in database for enhanced results.

- Image needs to have a high resolution, low resolution images can result in varying outputs and being a real time application the image captured gets blurred.

REFERENCES

[1] M. Arora, A. Jain, S. Rustagi, and T. Yadav, “Automatic Number Plate Recognition System Using Optical Character Recognition,” *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, pp. 986–992, 2019.

[2] M. Rhead, R. Gurney, S. Ramalingam, and N. Cohen, “Accuracy of automatic number plate recognition (ANPR) and real world UK number plate problems,” *2012 IEEE International Carnahan Conference on Security Technology (ICCST)*, 2012.

[3] J. A. Khan and M. A. Shah, “Car Number Plate Recognition (CNPR) system using multiple template matching,” *2016 22nd International Conference on Automation and Computing (ICAC)*, 2016.

[4] P. R. Sanap, S. P. Narote, R. B. Patel, and B. P. Singh, “License Plate Recognition System for Indian Vehicles,” 2010.

[5] M. T. Qadri and M. Asif, “Automatic Number Plate Recognition System for Vehicle Identification Using Optical Character Recognition,” *2009 International Conference on Education Technology and Computer*, 2009.

[6] R. C. Gonzalez and R. E. Woods, *Digital image processing*. New York, NY: Pearson, 2018.

[7] González Rafael C., R. E. Woods, and S. L. Eddins, *Digital Image Processing Using MATLAB*. Upper Saddle River, NJ: Pearson, 2004.

[8] H. Saghaei, "Proposal for Automatic License and Number Plate Recognition System

for Vehicle Identification", *https://www.researchgate.net/*, 2016. [Online]. Available: https://www.researchgate.net/publication/299858935_Proposal_for_Automatic_License_and_Number_Plate_Recognition_System_for_Vehicle_Identification.

[9] Jeffrey, Z., Zhai, X., Bensaali, F., Sotudeh, R., & Ariyaeeinia, A. (2013). Automatic number plate recognition system on an ARM-DSP and FPGA heterogeneous SoC platforms.*2013 IEEE Hot Chips 25 Symposium (HCS)*. Doi: 10.1109/hotchips.2013.7478331

[10] https://in.mathworks.com/

[11] https://www.researchgate.net/

[12] https://ieeexplore.ieee.org/

[13] LaVine, D., 2020. *When Is An FPGA Worth It And When Is It NOT – When Developing An Industrial Embedded System - Viewpoint Systems*. [online] Viewpoint Systems. Available at: <https://www.viewpointusa.com/industrial-embedded/when-is-an-fpga-worth-it-and-when-is-it-not-when-developing-an-industrial-embedded-system/>

[14] "Advantages of FPGA | disadvantages of FPGA", *Rfwireless-world.com*, 2020. [Online]. Available: https://www.rfwireless-world.com/Terminology/Advantages-and-Disadvantages-of-FPGA.html.

[15] "Automatic number-plate recognition", *En.wikipedia.org*, 2020. [Online]. Available: https://en.wikipedia.org/wiki/Automatic_number-plate_recognition

[16] "Literature Survey",*Shodhganga - Inflibnet*. [Online]. Available: https://shodhganga.inflibnet.ac.in/bitstream/10603/35020/10/11_chapter2.pd

[17] "Morphological Image Processing", *Cs.auckland.ac.nz*, 2020. [Online]. Available: https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/topic4.htm.