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DESIGN AND EVALUATE LICENSE PLATE DETECTION SYSTEM BASED ON SEGMENTATION

A DISSERTATION REPORT

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE
OF

MASTER OF TECHNOLOGY
IN
SIGNAL PROCESSING AND DIGITAL DESIGN

Submitted by:

SHUBHAM ANAND

2K18/SPD/09

Under the supervision of

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ELECTRONICS AND COMMUNICATION ENGINEERING

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Bawana Road, Delhi-110042

SEPTEMBER, 2020

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CANDIDATE'S DECLARATION

I, SHUBHAM ANAND, 2K18/SPD/09 student of M.Tech (Signal Processing and Digital Design), hereby declare that the project Dissertation titled "DESIGN AND EVALUATE LICENSE PLATE DETECTION SYSTEM BASED ON SEGMENTATION" which is submitted by me to the Department of Electronics and Communication Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

Place: Delhi **SHUBHAM ANAND**

Date: 11th Sep. 2020

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CERTIFICATE

I hereby certify that the Project Dissertation titled "DESIGN AND EVALUATE LICENSE PLATE DETECTION SYSTEM BASED ON SEGMENTATION" which is submitted by SHUBHAM ANAND, 2K18/SPD/09, Electronics and Communication Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi

Date: 11th Sep. 2020

Prof. S. INDU

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ABSTRACT

A continual upsurge in the volume of vehicles has been noticed over the past few decades with the increase in population all over the world. Therefore, tracking of vehicles depending upon the number plates is crucial to guarantee the control of vehicular traffic in competent manner. The vehicles can be detected on the basis of their tags with the help of a new image processing-based technology referred as ANPR (Automatic Number Plate Recognition) the expertise is ahead of time ubiquity to ensure security and traffic management. This system makes use of computer vision approach for extracting information regarding the abnormal state from a digital image using a computer. Almost all number plate localization algorithms combine many processes that result in a long computational time. Most of the image details are lost or image quality gets degraded as a result of complex, noisy content in images. The non-consistency of processes cause degradation which in turn affects the image quality. The car number plate detection has many stages. In this research work, technique of voting classifier is used for detecting the number plates of cars. For the purpose of voting classification, we have used a unique combination of classifiers. The voting classification proposed in this research work for the number plate detection is the combination of SVM and random forest classifier. The MATLAB and/or GNU Octave has been used for the evaluation of the proposed model. The efficiency of new algorithmic approach is examined with respect to accuracy, precision and recall. **The proposed algorithm gives accuracy up to 95 percent for the car number plate detection. Similar, observation with the Precision and the Recall that comes out to be 95.81 percent and 95.45 percent respectively.**

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SHUBHAM ANAND

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

AVRS	Automatic Vehicle Recognition System
RoI	Region of Interest
DIP	Digital Image Processing
JPEG	Joint Photographic Expert Group
SVM	Support Vector Machine
KNN	K- Nearest Neighbours
DT	Decision Tree
ANPR	Automatic Number Plate Recognition
NPR	Number Plate Recognition
AVPR	Automatic Vehicle Plate Recognition
MP	Matching Pursuit
CNN	Convolutional Neural Network
GPU	Graphical Processing Unit
ANN	Artificial Neural Network
RBF	Radial Basis Function
WT	Walsh Transform
HEVC	High Efficiency Video Coding
BPNN	Back Propagation Neural Network

ML	Machine Learning
HOG	Histogram of Gradients
LBP	Linear Binary Patterns
SMQT	Successive Mean Quantization Transform
MSER	Maximally Stable Extremal Regions
SWT	Stationary Wavelet Transform
ULEA	Unwanted Line Elimination Algorithm
VEDA	Vertical Edge Detection Algorithm
FCN	Fully Convolutional Network
EMD	Empirical Mode Decomposition
YOLO	You Only Look Once
SSD	Single Shot Detector
VIN	Vehicle Identification Number
VIS	Vehicle Identification System
VRS	Vehicle Recognition System
CPR	Car Plate Recognition
NPR	Number Plate Recognition
LPR	License Plate Recognition
GUI	Graphical User Interface. A visual way of interacting with a computer using items such as windows, icons, and menus, used by most modern operating systems.
ITS	Intelligent Transportation Systems. Aims to achieve traffic efficiency by minimizing traffic problems. It enriches users with prior information about traffic, local convenience real-time running information, seat availability etc. which reduces travel time of commuters as well as enhances their

	safety and comfort.
LICENSE PLATE	Small size (5x11cm in Europe) plate with distinguishing alphanumeric signs attached to a vehicle. Registration of the vehicle are done based on this and uniquely identified in databases by the text written on their license plate. The alphanumeric identification sign itself refers to a license plate.
LICENSE PLATE READER	A computing device either portable or fixed. It is embedded with a software for reading license plates and carries out detection/recognition of license plates.
LICENSE PLATE RECOGNITION	The way of transforming a digital image of a vehicle's number plate into a digital ASCII text of the registration number.
LPR PARKING SYSTEM	Parking system deployed with license plate recognition for automation.
MACHINE LEARNING	Algorithmic approaches applied by computer software for enabling computers to perform tasks in a better way by automatically analysing huge volume of input data.
MOBILE ANPR UNIT	Lightweight, mobile built-in hardware-software device for LPR.
MOTORWAY ROAD TOLLING	Channelized System made for the collection of funds (manual or automated) to recover the cost of building highways, roads and bridges. Further, their regular maintenance. The payment is made by motorists for the usage of a segment of road infrastructures.
NEURAL NETWORKS	An artificial neural network. A biologically inspired mathematical model for information processing following a connectionist idea to computation, derivate from the examination of bioelectrical networks in the brain formed by neurons and their synapses.
OCR	Optical Character Recognition. Electronic or mechanical translation of images of typed, handwritten or printed text into machine-encoded text, whether from a scanned document, a photo of a document, a scene-photo or from subtitle text superimposed on an image.

PATTERN RECOGNITION	An important area of computer science. Uses algorithms for processing digital pictures to make the extraction of valuable info from them.
SOFTWARE LIBRARY	A group of generally extremely optimised functions of subprograms delivered for developing software programs. Functions of the software library are called/invoked from the application software.
TRAFFIC SURVEILLANCE	Monitor traffic conditions, identify vehicles and their behaviour, gathers data related to road network use/abuse to provide aid to emergency services for better safety and cost reduction.
UI	User Interface. A software front-end used for providing an interface between the application and the computer user.
VEHICLE RECOGNITION SYSTEM	Integrated hardware-software computer devices designed and used for automatic vehicle recognition.

CHAPTER 1

INTRODUCTION

The first chapter of this report provides basic introduction of image processing along the significant task performed by this technology. The later section describes the ANPD (Automatic Number Plate Detection Process) with general steps.

1.1 Introduction to Image Processing

Image processing as a technique converts an image into its digital format by applying several operations. The operations implemented on the image help in the extraction of information concealed within the image pixels and make image more improve. The digital images are captured by using a scanner that makes the images digital or links the frame grabber board within the computers with a video camera. This whole process is generally referred to as digital image processing. Imaging is also known as image acquisition. Digital Image Processing (DIP) as a multidisciplinary technology involves the principles from a number of fields. Every image includes several regions or regions-of-interests (RoIs). These regions are commonly known as sub-images. In the images, every group of objects is represented as a base for a region within the images [1]. In order to carry out image processing, the images must be presented in digitized format.

First of all, the sampling of the input image is carried out on different lattices, further, the pixels are quantized using finite numbers of bits for performing the digitization process. In this way, the processing of a digital image is performed. The first process in digital image processing is the conversion of a digital image into an analogue signal. Then, scanning of this image is carried out as an output to showcase a digital image. Image processing has two very closer terms. These terms are known as computer vision and computer graphics. The images are arranged physically in computer graphics from the environments, physical models of lighting and artefacts. Similar to a number of animations, different image capturing tools are used to acquire image images from the

natural scenarios. The computer vision is identified as a good- quality image processing approach that interprets the objective contents of the image in the form of image sequence. Digital image processing makes use of extremely composite algorithmic approaches. In this way, it is possible to perform extremely complicated operations by simpler means. The technique of digital image processing makes a number of tasks possible that could not be performed using analogue way of image processing [2].

Image processing methods are generally categorized into two categories of Analog and Digital. The image processing methods based on analogue makes the processing of hard copies such as photographs and printout possible. Image analysts employs various interoperation means for implementing the visual techniques. The role of skills acquired by analysts is quite imperative along with the RoI (Region of Interest) in image processing technique. Association is one more substantial tool which is used by image processing based on visual methods. This means that image analysts implement an amalgamation of individual expertise and collateral data to process an image.

The technology of digital image processing makes use of computers for manipulating the digitized images [3]. The rough data gathered from multiple sources involves a lot of irregularities. This generates the need for applying several stages of processing to overcome these issues and obtain valuable information. Every image processing approach includes three common steps of pre-processing, image enhancement and display and information extraction. These steps help in the processing of all sorts of acquired data.

Fundamental steps implemented in digital image processing have been discussed below:

i. Image acquisition: In this primary step, the acquisition of a digital image is carried out.
ii. Image preprocessing: The main objective behind applying the next step of pre-processing is to make acquired images improved. This provision increases the chances of successfulness of various other processes as well.
iii. Image segmentation: In this step, the partitioning of an input image is carried out into a number of constituent portions by applying a suitable approach of image segmentation.

iv. Image representation: This step focusses on the conversion of original picture to make it suitable for computer processing.

v. Image description: The fifth step of image description is implemented to taken out the features providing quantitative information of interest or the features differentiating two or more category of objects.

vi. Image recognition: In this step, a label is allotted to an artifact according to the knowledge delivered by its descriptors.

vii. Image interpretation: Image interpretation steps make an ensemble of identified objects meaningful.

1.1.1 Important Operations of Image Processing

Following are the important operations performed by image processing:

A. Image Segmentation: Image segmentation refers to process to divide an image into multiple sub-regions. The division of an image is carried out into various sub-segments according to the client's requirement for resolving a particular issue. Image segmentation process divides an image into pixels. It is necessary to divide an image in proper manner by applying a good segmentation approach for improving the level of accuracy. A segmentation approach examines edges, extra records and constituents related to processing. The result of image segmentation process occurs generally in the form of complete image or groups of contours removed from image [4]. The image representation is simplified or modified by segmentation process so that image can be evaluated without difficulty. The process make image more attractive. The main purpose of image segmentation is image compression with objects' recognition and modification. The use of thresholding algorithms is quite common for segmenting images. A particular label is assigned to every image pixel by segmentation process to make certain that the pixel having similar label can share definite traits. Some popular image segmentation algorithms have been described below:

- Region Based: One of the most popular techniques of region-based image segmentation is threshold segmentation. The main motive of this approach is to decide the best threshold in accordance to a certain criterion in automatic manner and further use these pixels on basis of gray level to obtain clustering. Local and global thresholds are the two popular categories of threshold

segmentation. In the global threshold technique, the division of image is carried out into target and background regions. On the other hand, in local threshold methods, it is essential to select many segmentation thresholds. Moreover, the image is divided into many target regions and backgrounds using numerous thresholds [5].

- Edge based: In edge detection algorithm, edges are detected for identifying the image discontinuities. The edges are taken out and then compared with other pixel so that the pixel values can be recognized. On the other hand, the closeness amid edges is not mandatory in this approach. The information relevant to edges is taken out and then specific labels are assigned to every pixel. In addition to this, this approach helps in the extraction of the information from weak edges.
- Feature Based Clustering: Clustering is one of the commonly used methods of image segmentation. In this method, the clustering is carried out by transforming an image is into histogram. In this process, Clustering is performed according to certain requirements and object classification rules. The use of feature space clustering technique is quite common for segmenting the pixels in the image space with the similar feature space points. The segmentation of feature space is carried out based on the aggregation of points in the feature space. Afterwards, these points are mapped back to the original image space for getting the segmentation outcome.

B. Image Compression: The compression of records is signified among digital images through image compression. The matching data is extracted to store and further transmitted in extremely competent way by image compression method [6]. Image compression can be lossy or lossless. In lossless compression method, the data quality does not get affected before and after implementing compression. In lossy compression, however, data quality may get affected after implementing the compression technique. The lossless compression is generally performed in case of medical imaging, archival and technical drawing contents. Least loss of quality is tolerable for decreasing bit rate by lossy schemes. A popular image compression method is JPEG. This method is used to compress the Gray scale or complete coloured images. This method constructs 8 X 8 blocks by partitioning the image. This method performs block division to make certain that the overlapping is not carried out.

C. Classification: Image classification focusses on the extraction of information from pixels and labels of images. The essentials to provide a competent classification approach are a suitable classification methods and adequate number of training patterns. In general, the role of clients' requirements is crucial for a classification model. Researchers have developed a number of classification algorithms with the time. The classification algorithms presented so far can be categorized into two categories of Per pixel and sub pixel. Per-pixel classification algorithms are used most commonly. The sub pixel algorithmic approaches are employed in accordance with the varied pixel issue [7]. These algorithms generate extremely accurate results. Implementation of per-fields classification for the fine three-dimensional resolution data is the optimal answer here.

Classification algorithms can be either supervised or unsupervised. The supervised classification algorithms make use of the spectral signatures obtained from training samples. The signature file can be created easily from the specified training samples. Moreover, multivariate classification tools are used for classifying images. In unsupervised classification, output relies on machine with no communication with the client. Some popular classification algorithms include:

- Support Vector Machine: SVM belongs to the category of supervised algorithmic approach. This algorithmic approach is suitable for both classification and regression issues. But, the use of this algorithm is quite common for classification issues. This algorithmic approach plots every data point like a point in n-dimensional space with the value of every feature going to be the value of a specific coordinate. The variable 'n' represents the total number features. After this, the best hyper-plane, differentiating the two classes efficiently is figured out to carry out classification [8].
- KNN: This is a very simple algorithm used for classification. This algorithm stores all existing cases and perform classification of new cases according to a similarity measure (e.g., distance functions).The classification of a case is performed using a majority vote of its neighbors, while a distance function measures the case being allotted to the class that occurs most frequently amongst its K nearest neighbors. The case is merely assigned to the class of its nearest neighbor, with the K being 1.

- Decision Tree: Decision Tree is supervised machine learning algorithm. In this approach, a Decision Tree is used for creating a training model. This model can be used for predicting the class or value of the target variable by learning modest decision rules implied from training data (prior data).These algorithm initiates from the root of the tree for generating predictions about a class label for a record. Further, the values of the root feature are compared against the values of with the record's features. The branch equivalent to that value is followed based on obtained result and then the same process is applied on the next node.

D. Image Restoration: An image restoration technique focusses on generating a perfect image from a complete noisy image. In this way, the images whose quality got reduced as a result of some system error or noise restores again. There may be various reasons that degrade image quality [9]. The image quality can be restored using various existing techniques. One of the most commonly used approach is the modelling of that image whose quality is degraded because of certain reasons.

E. Image Enhancement: The key aim of image enhancement process is to improve the image appearance. Since images are gathered from multiple sources, therefore image quality may get degraded often due to some factors. The image elements are improved through image enhancement so that the images may be clearer. The visual effect is enhanced which in turn improves the information content of pictures. This method performs image analysis, feature extraction and displays images. In this process, the algorithms are designed on the basis of the applications and cooperation. Some well-known image enhancement techniques involve noise filtering, histogram modification and contrast stretching.

The spatial domain methods are applied on along pixels. These methods bring changes in the pixels' values for getting the required enhancement. In order to do so, techniques working directly according to the pixels of images are used [10]. The images based on frequency make use of frequency domain methods. This method works on the orthogonal conversion of image rather than the image itself.

1.2 Applications of Image Processing

Some popular applications of image processing include:

i. Face Detection: This application of image processing method aims to detect crucial facial features while ignores all other features. This method is applied to identify particular features including position and magnitude of some specific faces. Various algorithms are used for detecting the frontal facial features. This technique can give answer to common and complex problems of multi view face detection.

ii. Digital Video Processing: Video processing is a major part of signal processing. This video processing is applied in various engineering and computing applications. The video files or video streams are the input and output signals are achieved.

iii. Remote Sensing: Remote sensing refers to the process of acquiring small- or large-scale information signals from any object. This application makes use of various wireless realistic sensing devices. A range of devices misemployed gather information about a specific object from compilation of numerous data signals [11]. This process is referred as real-time remote sensing. A parolee is generally monitored using a number of remote sensing methods.

iv. Biomedical Image Enhancement & Analysis: The biomedical image enhancement is a challenging task for the diagnosis of biomedical images. This application intends to enhance the biomedical scans. There digital sensors are used by the real-time digital techniques and analogue imaging modalities lately as the technology becomes more advanced. The digital images consist of individual pixels based on the discrete intensity levels or different colour values. The pixels can be successfully processed and objectively evaluated once the biomedical image improvement and proper analysis is performed.

v. Biometric Verification: The human beings are recognized or identified automatically through biometric verification according to their behaviours or features. Biometrics recognition is a competent process of identification and access control. Biometrics recognition can be used for identifying individuals occurring in groups [12]. This main purpose behind designing this method is to make sure that merely the legal client can get the access of rendered services. Hence, a pattern recognition system is designed on the basis of the acquired biometric data of an individual. The operating principle is

defined using extracted set of defined features from the gathered data. In addition to this, the comparison of template set from the database and the feature set is carried out. A biometric system works under verification mode depending upon the type and mode of application.

vi. Signature Recognition: Signature verification and recognition is one more well-known application of image processing. A decision is made in this approach according to the image of signature and a few image samples of genuine signatures of the user. Further, certain factors such as unsharp corners, non-smooth curves and askew lines make the handwritten signatures inaccurate. In addition to this, unlike the handwriting that is supposed to be written on baseline in straight position, the different sizes of fonts and orientations occur. Therefore, a robust handwritten signature recognition system needs to be developed necessarily by keeping all these aspects in mind.

1.3 Automatic Car Number Plate Detection

The massive growth in the number of vehicles have been noticed over the past few decades with the increase in population all over the world [13]. Therefore, tracking of vehicles depending upon the number plates is crucial to guarantee the control of vehicular traffic in competent manner. The vehicles can be detected on the basis of their tags using a new image processing-based technology referred as ANPR (Automatic Number Plate Recognition). the expertise is ahead of time ubiquity to ensure security and traffic management. This system makes use of computer vision approach for extracting information regarding the abnormal state from a digital image using a computer.

Almost all number plate localization algorithms combine many processes that result in a long computational time. Most of the image details are lost or image quality gets degraded as a result of complex, noisy content in images. The non-consistency of processes caused gradation which in turn affects the image quality. One of the basic solutions of this issue is the adjustment in camera position. The camera adjustment solution recommends the image capturing of car from certain distance so that the environmental condition could not create hindrance in image acquisition and a clear visual of number plate can be obtained. However, camera size adjustment in case of fast cars is not so easy as the best moment of exposure cannot be assured [14].

Figure 1.1 shows a commonly used automatic model for detecting and recognizing license plate of vehicles.

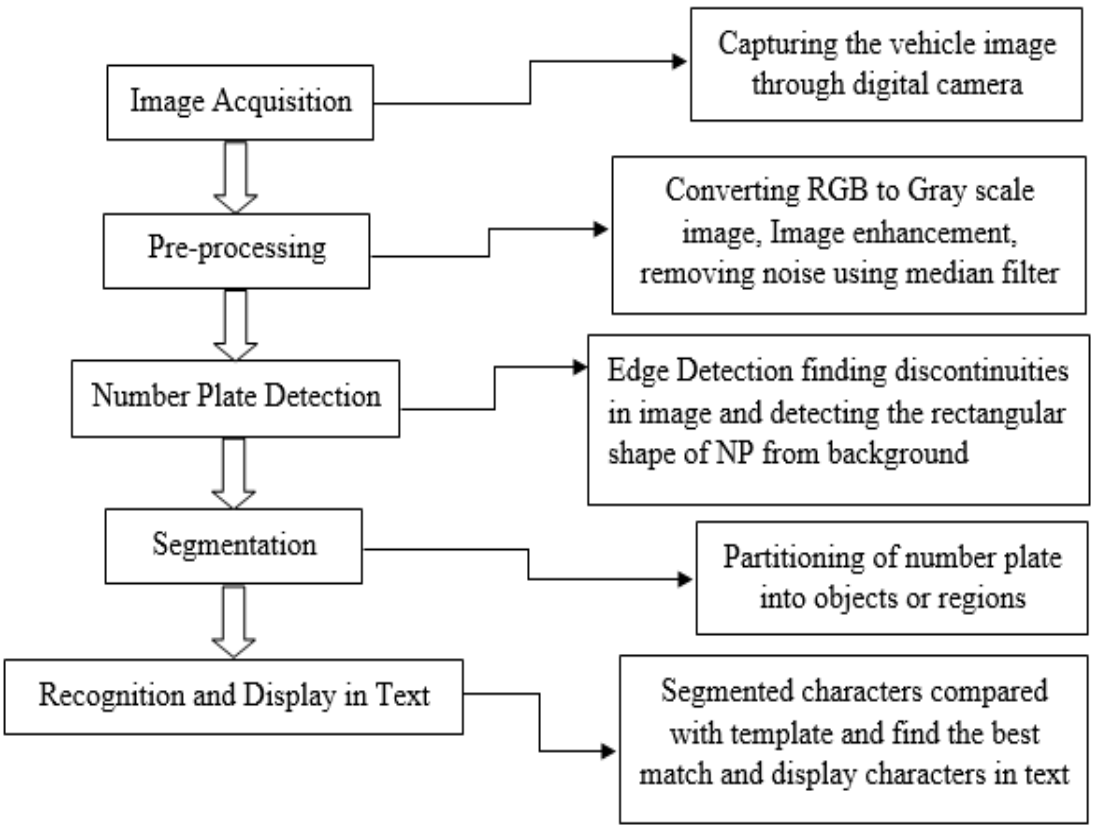

Fig. 1.1: Process outflow of Vehicle Identification

The whole process for detecting and recognizing number plates is generally decomposed into four crucial steps.

a. Pre-processing

b. Localization of license number plate region

c. Character Segmentation of license number plate

d. Character Recognition of license number plate

There is the brief explanation of these stages:

A. Pre-Processing

The image or video of vehicle is taken by deploying a camera of at least 13-MP resolution. The recognition of the number plate of these images is performed. The

image is converted into frames in case of producing a video and the selection of frame is performed on the basis of video length and time when it has clear frame vehicle. The noises are removed with the help of mean or median filters. Consequently, the NPR is enhanced. Nevertheless, this procedure is majorly emphasized on the frequency along with the noise removal. Therefore, the edge detection is carried out on images. The detection of edges of rectangular plate is considered at first as most of the number plates have rectangular shape [15].

B. Localization of the License Plate

One of the fundamentals intend of this technique is to recognize the accurate position of number plate area available in a digitized picture. Therefore, a sub-picture that comprised merely the license plate is considered as output. Two phases are included in it which are defined as

a. To determine the precise location of number plate.
b. To localize a huge bounding rectangle of the number plate.

The main benefit obtained using the LNPs of vehicle are Black & Yellow or Black & White that comprised of high contrast regions in an image. The positioning of alphanumeric characters is done in vertical within the similar line and these characters are diverse in terms of the horizontal intensity in the license number plate. The sharp variation is present in brightness of the alphamerical fonts and contextual of a picture. This intensity changeover is carried out for detecting the area of license plate. Some of the edge detection techniques are implemented to recognize the boundaries of an image. These techniques also assist in recognizing the edges which have sharp variation in intensity gradient of image. An enormous intensity contrast is comprised within an image. So, the detection of edges is carried out in case of unexpected variation in intensity among pixels. The edges of number plate are recognized for reducing the data and for eliminating the unessential information. Furthermore, the structural properties related to an image are also preserved. Each pixel is located in an image by computing the gradient of image.

C. Segmentation of Characters on License Plate

The connected objects of an image are scanned after the extraction of area of number plate. The connected components are labelled with special label when their recognition

is completed. A number of labels are assigned to every component so as they can be distinguished from one another. The number plat is classified into several sub images and one character is preferred by every image under the character segmentation procedure. The character recognition is considered very crucial in system of detecting the vehicle plate as this process is planned on the basis of segmentation [16]. The improper segmentation leads to cause inaccurate recognition. Therefore, the superior outcomes are obtained after dealing with these problems. The commonly utilized techniques in plate segmentation are defined as:

- License plate segmentation using pixel connectivity: The pixel connectivity is carried out to assign labels to the characters under this method. Only those labeled pixels are taken in account as candidate license plate characters that have similar size, perimeter and aspect ratio. The number plate segmentation technique is not proved appropriate during the availability of broken characters.
- Segmentation of license plate by prior knowledge of characters: The resizing of number plate is done into a template of fixed size under the initial stage. The fixed location is assigned to every character in this template. The extraction of character is done from these fixed positions. These techniques are easy but provide an error in case of incorrect of preceding knowledge of the characters which is known.
- License plate segmentation using character contours: Contours modeling can be carried out to extract the characters from number plate. The marching method was utilized to discover the rough location of character in this technique [17]. Afterward, attributes of characters are employed for discovering the actual position of character. These techniques are slow and lead to produce distorted contours.
- License plate segmentation using combined features: Two or many methods mentioned above could be integrated to perform the plate segmentation in effective way. The position of characters is detected in the number license plate using hybrid algorithms. These techniques are more reliable, but these are computationally complex.

D. Character Recognition of the License Plate

Character recognition is the last phase in this procedure. In this, the conversion of image text is done into characters using recognition. The template matching is utilized to compare characters from LP with the alphanumerical dataset. The matching procedure is carried out for the comparison of acquired sub-image with all possible positions of database within template images. A superior matching is obtained from template images by computing all the numeric indices for every character. The techniques utilized in character recognition are described as

Character recognition using raw data: The characters are identified in this technique using template matching. It also computed the similarity amid the extracted character and pre-stored templates. The most similar character is considered as a target [18].

Character recognition using extracted features: Initially, the extraction of attributes of characters is performed. These extracted features and pre-stored feature vectors are compared for identifying the correct character. This technique is quicker than the template matching because the numbers of attributes are less than the number of pixels.

1.3.1 Challenges and issues in license plate detection and recognition

There are various difficulties which are faced due to the differences in the license plate types or settings for recognizing the number license plates. Some of these difficulties which are determined on the basis of review of literature regarding AVPR and study of some existing AVPR systems are defined as:

i. Variety of text: The registration number on license plates is written in distinct languages and diverse fonts styles. Indian license plates of vehicles consist of license plate numbers of various different font styles and size because they have not any standard format. Images related to 2 vehicles that have a license plate number can be written using different font type and size.
ii. Extreme Weather Conditions: In some cases, the automatic LPR systems are not proved efficient due to some bad environmental conditions and hindrances. In this situation, the security measures might be disgusted and there is more manned surveillance.
iii. Privacy concerns: The fact that images and records are preserved, and stored makes arise of some privacy concerns [19]. An individual is scared that there

may a misusing of whereabouts of someone in all these footages. This leads to data thefts or people with all types of nefarious intentions. But it is stated by the experts that recognizing the license plates has not any effect on the privacy of any individual.

iv. Unnecessary text and screws: In some cars, some extra text is written on license plates instead of the registration number. Moreover, the license plates may also include screws and frames. This unnecessary information on license plate has impacted the accuracy for recognition.

v. Faded text: Poor quality of text on number plates causes the complication while recognizing the text in the image in accurate manner. In these images some of the characters on the registration plate are not present due to which the recognition accuracy is affected.

vi. Presence of noise: The noise and low contrast are occurred in images when these images are taken from the environment in the presence of uncontrolled illumination. These images may consist of impurities. Noise in an image is taken in consideration as variation in intensity value of pixels related to the image. The image of the vehicle is degraded, and the recognition accuracy is influenced in the presence of noise [20].

vii. Location of license plate: License plates are positioned on the lower middle part of the vehicle. But all the manufacturers of vehicles are not utilized this standard. LNP could exist in various locations of the image and it is considered as challenge in AVPR localization of license plate.

viii. Omitted text: The image of the vehicle that have license plates comprise of eliminated characters. There are some alphabets of the registration number which are not present. It may mislead the AVPR system for recognizing the license plate number in correct way.

CHAPTER 2

LITERATURE SURVEY

We have done a thorough literature survey and corresponding references have been provided at the end of the report under the title REFERENCES. Brief description for each of the individual relevant references has been provided below.

Khin Pa Aung, et.al (2019) discussed that there were three procedures comprised in basic ALPR system in which the LP was detected, the character was segmented and recognized [21]. A major objective of the presented system was that the LP was detected on the basis of image processing which was an essential stage for entire presented scheme. Therefore, an edge-based approach was carried out in the presented system for every colour of plate and its area was stay same as remain it had a white boundary. After detecting edge, morphological operation was implemented for adding or eliminating pixels from the objects within a picture. Therefore, the extraction of LP was performed in accurate manner. At last, only the area of plate was extracted in exact manner by utilizing the bounding box technology.

Shigeharu Miyata, et.al (2016) suggested a novel technique to detect the number plates in which the LP was represented, and the outcomes were also described at the time of execution of this technique for detecting the LPs in Japan [22]. A SVM on the basis of negative and positive examples was implemented for determining that the candidate area was a license plate or not. At last, the location of the LP was recognized. It also analyzed the impact of dissimilarities in brightness and number of positive and negative examples utilized to learn on the number plate and non-LP images after applying suggested technique. The suggested technique efficiently provided the detection rate about 90%.

NazmusSaif, et.al (2019) proposed a system for recognizing the number plate automatically which was utilized for detecting and recognizing Bangla LPs from an image of vehicles [23]. A database was developed which comprised these kinds of vehicles. Initially, the license plates were detected in an input image from this data set. The CNN model was carried out for this. The detected LP image was taken for a novel input that had to be inserted in the same Convolutional Neural Network was utilized in order to segment and identify the number plate's numbers. There were two hundred images for testing this model and provided an accuracy that was evaluated as 99.5%. The Google Collaboratory's Nvidia Tesla K80 GPU was employed to test this model for speed and 9 frames' pace was obtained in terms of every second after the detection as well as recognition of the numbers of LP in a video.

K Mahesh Babu, et.al (2016) analyzed that LPDR acted significantly and the identification of vehicles registration number was required at a certain distance [24]. There are four main stages of this paper. The digital camera was deployed to capture the expected vehicle image; adjusting the image, removing noise with filters and converting the image into gray scale under the pre-processing. The exactions of license plate region had comprised to discover the edges within a picture in which correct position of number plate was placed and cropped it to frame having a rectangular shape. Segmentation was proved promising while identifying a licenses plate of vehicles and the intelligibility to identify the character depending upon on the segmentation process. The utilized technique was easy and suitable. Initially, the Bounding box technique was carried out to segment every character in the image. At last, every character was identified. The template matching technique was implemented to identify every character on the vehicle's number plate.

Debkumar Chowdhury, et.al (2019) suggested an adaptive method for detecting the LP of vehicles based on computer vision [25]. There were three modules comprised in the suggested technique. First was to delete license plate, second was to segment the characters and third was to generate a Text Box. The number plates were not clear for the cameras and had included some dust and scrapes. Consequently, the complications of the adaptive system of recognizing the LP were maximized. Numerous law and governmental agencies had utilized ALPR because of its effectiveness and efficacy. Public safety agencies deployed this system for collecting and storing the applicable

information regarding people and for monitoring the vehicular activities. The ALPR was proved as one of imperative tools for the Law Enforcement Agencies.

Rachna Boliwala, et.al (2016) analyzed that the ALPD was one of the technologies utilized for reading the LP from a picture that had a motionless or portable image of a vehicle [26]. This paper had taken in account the variation of kind of LP and some environmental illuminations. A special type of surveillance cameras were deployed in this technology for tracking & recording the vehicles registrations and for tracking their movements easily. It was not easy to maintain the track of every means of transportation and for discovering the illegal actions because of the emerging growth of vehicles worldwide. Thus, it was required for the respective authorities to monitor the track of all these vehicles. This technology was introduced for simplifying their huge task that proved useful in their management.

Nauman Saleem, et.al (2016) recommended a novel approach to utilize the ALPR system effectively and quickly [27]. This approach had carried out the vertical edge detection algorithm and image normalization method employed for eliminating undesired edges. Different image processing schemes were combined to extract the number plate region. The template matching was carried out to OCR so as the character was identified. There were 500 real time images which obtained under various illumination conditions and from diverse scenes had employed for testing the algorithm. The accuracy obtained from recommended technique was evaluated as 84.8% and the execution time was less than 0.5 sec.

Chuin-Mu Wang, et.al (2015) suggested a LPR system that carried out the NN concept [28]. The corresponding workflow was developed in the suggested system and completed using PC for creating a fast and accurate system. A major algorithm was comprised in this system prior to image processing, to detect and take the place of LP, its cutting component, to extract its component features, for recognizing the LP and other components of various parts. The preliminary size of the area of localization outcomes were considered as the foundation for the judgement of detected abnormal number plates and research. Whereas, the place was utilized to obtain the enhanced position and the accuracy of the cutting plate element was also improved with it. The comparative features of the target element and background had utilized for detecting

the colour change, for recognizing the elements borders and cutting under the plate element cutting part.

Golam Rabbani, et.al (2018) presented a technique to detect and identify the license plates of vehicles automatically [29]. There were four major modules in which the location of LP was detected and extracted had comprised in this system. Afterward, the characters and words were segmented and at last, the characters and words were identified. A common standard was utilized in the BRTA for vehicle license plate. A threshold value was employed for detecting and extracting the license plate on the basis of this analysis. Later on, the connected components were employed to segment the character. The deep learning tool named CNN was implemented to identify the character. A customized dataset of Bangladeshi number plate was designed to carry out for the presented method because of the shortage of the standard data set. The presented system provided the accuracy of 95.42%.

B. Pechiammal, et.al (2017) investigated an algorithm to ALPR system for which a variety of approaches had employed [30]. This technique had three segments. A vehicle number plate extraction was carried out to introduce ALPR system in this presented framework. This paper suggested other strategy in which Gabor filtering had employed to recognize the character within gray scale picture. Gabor filters that were exceptionally suggested for quantifiable data containing character structures split the components from gray-scale character images in direct way. A sub image of target image that coordinated a template image was discovered for utilizing a system named Template matching. The outcomes of experiment demonstrated that the suggested approach was better and efficient.

Y. Y. Nguwi, et.al (2015) described the significance of recognizing the LP and its equivalent application in diverse nations [31]. This study reviewed several techniques to recognize the number plates. There were many systems which had potential for providing good recognition rate higher than 90%. But literature that reported the LPR in images having noisy background was required. The system which had potential for tolerating noise level about 20% was suggested and reported. The filters were integrated with morphological operations and executed to segment the number plate. After that BPNN was deployed for the recognition in it.

Mansour Nejati, et.al (2015) suggested a novel approach for Iranian vehicle LPR [32]. There were four stages included in this suggested algorithm. There were 3 consecutive frames of a vehicle that had taken through diverse disclosure times had carried out for the implementation of suggested LPR approach for enhancing the accuracy and robustness of recognition. The outcomes of experiments conducted in practical situations demonstrated that the accuracy obtained from the suggested approach was evaluated as 95.39% to localize the LP and total precision obtained was 92.45% after recognition.

Nandan More, et.al (2015) discussed that the Traffic management system was carried out to recognize the number plate for them whose owner had dumped traffic laws or for discovering the vehicles which were stolen [33]. The number plate recognition was recommended for which the ANN and WTFS was carried out on the basis of WT function. The recommended technique was compared with the technique based on correlation to detect the number plate. The outcomes obtained from the experiments revealed that the recommended technique performed superior than the methodology based on correlation. The multi-class RBF NN optimization assisted in the modification of matching process to recognize the number plate.

Hussni Mubarak, et.al (2017) discussed that the stages and phases of action were reviewed in this paper for which ANPR method of image input, pre-processing etc. had implemented [34]. The images were captured using camera. Some filters were carried out for improving the image and to prepare it for the next phase under the pre-processing stage. Morphological procedures had employed for the edges; Division the region property was carried out and the pattern matching technology was executed under the process of recognition of the contents of the image. A tool was offered by the researchers on the basis of earlier studies for extracting the numbers of electronic plates. There were 33 samples of Sudanese car plates deployed for testing the experiment. The experimental outcomes proved that the efficiency provided by the presented model was 90.06% for extracting the plate numbers.

Jung-Hwan Kim, et.al (2017) suggested a new algorithm to detect and recognize the license plate for which black box image was executed [35]. The suggested LPR system was categorized into three phases. The noise in the image was eliminated through the Gaussian blur filter. Subsequently, the modified canny algorithm was employed for

detecting the license plate edge. The morphology and SVM were carried out for determining the candidate image of license plate secondly. At last, the K-NN classifier was implemented for the identification of the numbers and characters. It was observed in outcomes of experiment that the execution of the license plate detection and recognition algorithm was done effectively.

Muhammet Sebul Beratoğlu, et.al (2019) described that the HEVC analyzed the data which the new video compression standard had compressed and also represented that there was not required any full decode process for detecting the number plate of vehicle [36]. A photograph was generated in which HEVC block partitioning structure was demonstrated. This structure was present when the compression procedure was started. The training of CNN was done in which these types of images had utilized for discovering the corresponding number plate regions. The compression was performed by training the second CNN in pixel domain and the outcomes which had acquired were also represented.

Elena Medvedeva, et.al (2020) recommended a vehicle LPR system. The major objective was to implement a novel technique so that the number plates were detected [37]. This technique was planned on the basis of detecting the contours and carrying out statistical knowledge related to them. A mathematical image model was utilized with two states for detecting the contours. The bit planes of the senior obtained from the digital image was suggested to detect the number plates so that computational resources were mitigated. The suggested technique had potential for alleviating the computational cost of the license plate which was detected. Consequently, the license plate symbols of vehicle were recognized. The obtained accuracy of character recognition was 92%.

S. Saraswathi, et.al (2017) discussed that there was some common framework of phases for processing included in the LPR systems [38]. To detect the number plate was one of the difficult procedures as the format of the number plate was available in a huge variety and the other fact was that the environmental circumstances were caused an issue within the image acquisition phase. The effective plate detection acted significantly for segmenting and recognizing the character accurately. A comprehensive learning and examination were presented on the methods that were at the front position of detecting and recognizing the license or number plate.

Yasir Elhadi, et.al (2019) suggested an automatic LPR system that was utilized for the extraction of number of license plate of the vehicles for which ML models and image processing algorithms had carried out [39]. There were three consecutive phases implemented in this system and it differed from the methods which were carried out for obtaining the output. In the initial phase, the license plate was located in a given image. For this purpose, CNN based on faster region was implemented that had potential to recognize the regions with objects on the basis of regions network. It had also potential to categorize the detected objects. In the second phase, the image processing algorithms were applied to segment the plate. The CNN was executed for identifying the segmented digits in the last phase. The outcomes demonstrated that the vehicle number plate was detected and identified on real images using the suggested system in successful way and the overall obtained accuracy was evaluated 93% using100 images.

Nawaf Hazim Barnouti, et.al (2017) emphasized on developing an Automatic system for identifying the licence plate for the new Iraqi LPs for which BPNN was implemented [40]. The MATLAB software package was employed to conduct the simulation of the suggested technique. The number of license plate was recognized for vehicles; the number of NP was compared with a built-in database and provided the data regarding the correct means of transport using this software. At last, it determined that the entry of this vehicle was permitted in a particular area or not. This software was capable for recognizing the license plates while addressing the bad quality images of vehicle license plate.

Wang Weihong, et.al (2020) proposed an application of deep learning for recognizing license plate and this study had included some major objectives. At first, the enhanced algorithms were established from the 3 major technical difficulties [41]. There were two categories of these algorithms in accordance with this procedure: the direct and the indirect detection algorithms. The analysis of algorithms for detecting current license plate and for recognizing character had done in second. Thirdly, the comparison of datasets, precision and time of diverse systems of recognizing the license plate was carried out. Fourthly, the existing publicly available datasets were compared and demonstrated in terms of the number of images, resolution and environmental complexity. For the future research, the outlook was provided for recognition license plate.

Madhusree Mondal, et.al (2017) analysed that the CNN was utilized to detect and recognize the image of car plate number that was the paramount work. The attribute learning capabilities of CNN influenced this work [42]. A still camera had deployed to acquire the number plate pictures. The positions of the vehicle were recognized from the LP using the Self-synthesized characteristic involved in Convolutional Neural Network and obtained accuracy was evaluated 90% including very low training size. The presented approach was demonstrated robust even on the distorted, tilted and illuminated datasets.

Aswathy A V, et.al (2019) discussed that number plate identification was the practical application in image processing method [43]. Some technique had carried out on the images of vehicles for reading the vehicle registration plate in the proposed method. This technology consisted of various applications that emphasized on the intelligent system of transportation. The number plate of vehicle was read from an obtained image computer system which was deployed in it. The registration was a numeric or alphanumeric identity which assisted in recognizing the vehicle owner in the issuing areas of registration of vehicle. The colour vehicle image contained in computer and the plate number of that vehicle was shown in the output. The Template matching scheme had implemented for identifying the registration plate of vehicle.

Ievgen M. Gorovyi, et.al (2015) described that number plate detection was one of major stage using which the performance of system for recognizing the number plate was influenced [44]. A novel approach was suggested to achieve this objective. A suggested approach designed on the basis of detecting text areas for which stroke width transform was employed. The specifically introduced image pre-processing technique was utilized on the basis of a set of morphological operations and contour examination to detect more NP candidates. The NN whose learning was done from the training data set had carried out in order to categorize the candidates of final number plate. It was observed in the outcomes of experiments that the developed technique had provided the high performance.

Coşku Öksüz, et.al (2015) recommended an automatic number plate recognition technique along with low computational load for detecting the licence plate area for which character characteristics were deployed [45]. Dissimilar to classical Sauvola scheme, the output was weighted in terms of the pixel luminance values. Thus, the

removal of dark areas was done with the detection under pre-processing stage. Subsequently, the connected component analysis had carried out to eliminate the areas in which a character property was not represented. The horizontal projection was employed to detect the character regions later on. The outcome obtained from experiments indicated that the recommended technique was quicker and provided superior performance for the detection.

Prashengit Dhar, et.al (2019) emphasized on constructing an algorithm to identify the NP of Bangladesh for which image processing and ML framework was implemented [46]. There were three stages included in this algorithm in which the plate was detected using shape verification, tilt correction and the number was recognized. Various techniques were carried out to perform detection. The robust distances were deployed to borders vectors to verify the shape so that the noisy object was eliminated. The horizontal tilt correction was implemented prior to character segmentation. After that bounding box parameters were utilized to extract the characters from the extracted plate. At last, HOG and LBP attributes were employed to perform the recognition. The characters were classified using the Adaboost classifier. The outcomes obtained in experiment revealed that the proposed system provided highest accuracy for detection and recognition.

Jissy Joseph, et.al (2019) investigated a LPR system in which there was not any human intervention [47]. Initially, the SMQT was employed to pre-process the image. The license plate was localized within the pre-processed picture. The comparison and analysis of two methods was performed. The MSER and SWT algorithms had carried out for detecting the text region in the image in the first technique. Otsu - thresholding was utilized in the second technique after that morphological operations were implemented. After recognizing the area of license plate in accurate manner, the character was segmented and identified for recognizing the license plate number.

Naaman Omar Yaseen, et.al (2019) proposed a novel dataset known as NI-VI of three provinces for vehicle images [48]. This dataset had employed 1500 pictures. The handled cameras were deployed to collect these images from real-time so that real-time data set was developed of photographs of vehicle. The major objective was to design a novel data set for vehicles number plate having Arabic fonts under diverse and complicated situations. There were three types of images which had comprised in this

dataset. In addition, some images were developed for various bad weather situations. This dataset also took some filthy plate images. The fundamental objective of this dataset was that a realistic dataset was offered and generated for ANPD and ANPR systems.

Yuxin Shi, et.al (2018) suggested a detection algorithm on the basis of CNN and visual attribute for dealing with the issue of recognizing the license plate [49]. Initially, the artificial feature extraction was executed for producing a certain number of candidates bounding box. After that, the bounding box had carried out as input in the cascaded CNN to perform further verification and regression. The results obtained from number of experiments revealed that the suggested technique had provided the efficient outcomes in terms of accuracy and speed.

Naaman Omar Yaseen, et.al (2019) recommended an effective model for detecting and positioning the vehicle's number plate which was provided in color images [50]. Various attributes in place of single attribute had deployed for enhancing its performance on the basis of multi descriptors. The multi- boosting model named AdaBoost had carried out on the basis of HOG descriptors that were utilized to localize the ROI of the particular images of vehicle. A novel NI-VI dataset was established that assisted in testing the recommended model. The Arabic font had utilized in the license number plates. Every image included in this dataset was captured in several situations and diverse weather conditions for the simulation of all realistic examples regarding vehicles. The recommended model had provided the accuracy of 89.66%.

Amr A. El-Latief, et.al (2017) intended a bio-inspired classification algorithm using which enhanced accuracy was obtained though the number of pictures utilized during training was relatively small. The presented classification algorithm was implemented for detecting the issue of the Egyptian license plate [51]. A number of license plates of diverse sizes and orientations were detected even in complex environment. There were two phases in the presented approach. At first, a sliding window and a weak classifier had employed to extract the candidate plate regions. The candidate areas were categorized into the suitable plate style using another classifier with more attributes in second phase. This approach was implemented on the Egyptian License Plates including three distinct plate styles. There were forty images of each category had

deployed as training data to evaluate the intended approach and the success rate obtained rate from it was 92%.

Hasan Imaduddin, et.al (2018) proposed an Indonesian LP detector in which DL technique included CNNs with only information from a camera had utilized [52]. The license plate number of every vehicle was detected automatic way using this system in case of entry of riders in the zebra cross region. At that time, the license plate of rider was detected and stored. In addition, the system was capable for detecting the plate on the vehicle which was on high speed after counting on the counter time. The license plate was detected with the proposed system when the vehicles exceeded the speed limit.

Miguel Molina-Moreno, et.al (2019) presented a model based on scale-adaptive deformable part which was planned on the basis of popular boosting algorithm which was an automatic models scale in the training stage. For this purpose, the most prominent attributes were chosen at every scale and the evaluation at different scales was avoided for mitigating the test detection time [53]. Moreover, an empirically constrained-deformation model was integrated in this model which was adaptable to various levels of deformation as represented through different local attributes in license plates. The experimental section represented the robustness of the presented detector and also revealed that it was scale and able to perform in quite different scenarios. Two datasets were employed to perform the experiments. The outcomes indicated that the presented technique performed superior as compared to the other existing techniques.

Ashwathy Dev, et.al (2015) analyzed that the vehicle was recognized using the license plate as it was unique for every vehicle. A fast method was suggested to recognize the license plate of vehicle [54]. Initially, adaptive thresholding was implemented to binarize the input and The ULEA improved the image. Afterward, the VEDA was executed for detecting the vertical edges included in a photograph. The extraction of number of possible locations of candidate LP was done from which original LP was detected.

Hanit Karwal, et.al (2015) described that implementation of automated systems was required due to the exponential increasing the number of vehicles for handling the vehicle information [55]. The information was necessitated to manage the traffic and to

alleviate the crime. The number plate recognition was one of the efficient techniques to recognize the vehicle automatically. There was some existing algorithm planned on the basis of the principle of learning consumed much time and expertise prior to generate the acceptable outcomes however did not provide the accuracy. The presented algorithm executed an effectual technique to identify the number plates of Indian vehicle. This algorithm utilized to deal with the issues related to scaling and recognition of characters' region and provided a good accuracy which was evaluated as 98.07%.

Ohnmar Khin, et.al (2017) suggested a technique for detecting of the license plate for Myanmar vehicles which were taken under various environmental conditions as the difficulty was faced in defected images [56]. This paper suggested a horizontal and vertical dilation, skew angle detection and automatic bounding box for the detection of number plate from input pictures. The experimental outcomes demonstrated that obtained accuracy using suggested technique for detecting license plate was computed 99%.

Ayman Rabee, et.al (2014) recommended a consistent approach for detecting and identifying the license plate. To achieve this, mathematical morphology and SVM had executed [57]. There were 3 major phases involved in this approach to detect license plate and for segmenting & recognizing the character. The performance of localizing the number plate and segmenting the character was enhanced under serious imaging situations using pre-processing phase. The edge detection, mathematical morphology was carried out in the initial phase and connected component analysis was performed in second phase. In the last phase, the Support Vector Machine was utilized for developing a classifier so that the input numbers of LP was categorized in one of nine classes. There were 208 car images with diverse attributes deployed in this algorithm. The obtained accuracy to localize the license plate was computed 97.60%, to recognize the licence plate was90.74% and to recognize the number 97.89%.

OhnmarKhin, et.al (2017) analyzed that LPR was not available for detecting and recognizing the number plates from diverse angles [58]. The major objective was that the different angles of the license plate had to be detected with the non-fixed Number Plate Recognition system. Thus, the horizontal and vertical dilation, skew angle detection and automatic bounding box had suggested for detecting the license plate.

There were 4 diverse categories of Myanmar license plates had employed in the suggested technique. The selection of one car from each was done into 4 distinct kinds of angles in different circumstances. The results obtained from the experiments revealed that a high precision was provided through the presented technique. The achieved favourable outcome rate was evaluated 97% on 100 license plates.

Zhi-Kai Huang, et.al (2018) discussed that license plate of vehicle acted significantly to detect the stolen vehicles, control the traffic volume and ticket the speeding vehicles [59]. A deep learning technique was suggested to detect the car license plate. A region proposal network was trained and the output of the RPN was carried out to train the Region based Convolutional Neural Network. RPN was integrated with R-CNN to mitigate the training time for complex huge images to a controllable range. The detection time of the target area was also reduced to quasi real time and the satisfactory accuracy was obtained. It was a practical LPD algorithm

Naaman Omar, et.al (2020) suggested a cascaded deep learning approach for developing a capable Auto number plate detection and recognition system utilized for the vehicles of northern Iraq [60]. The computation of performance of this technique was done with respect to detection and recognition. The recall, accuracy had utilized in detection and the classification precision was employed for recognition. The efficiency of the suggested technique for detecting and identifying the license plate was proved in acquired outcomes. The obtained recall was evaluated as 92.10%, accuracy was 94.43% and F-measure scores was 91.01%. Furthermore, the precisions for Arabic numbers was computed as 99.37% and the city labels was obtained as 92.26%,

X. Ascar Davix, et.al (2020) suggested a method named kernel density function with the binary method was carried out to pre-process [61]. The filtered binary value of the image was utilized to find the position of car plate for which the binary value was multiplied with original value of the picture. The suggested technique was performed better than improved methods through a huge margin with respect to the accuracy for detection and efficiency of run-time. The obtained accuracy using suggested technique was evaluated 98.1% for detecting the number plate and the cost of evaluation was evaluated as 0.452 s.

Muhammad Rizwan Asif, et.al (2019) recommended a new illumination invariant technique for handling the multi-national vehicle NPs of diverse colours and modes [62]. At first, the tail-lights of vehicles had detected red corona using for developing a ROI as the number plates available in a vicinity of its tail-lights. An exclusive approach which preserved edges of LP had deployed to acquire the vertical edges in every ROI so that performance was enhanced. Afterward, the license plate region was differentiated using Heuristic energy map. The detected regions were authenticated for extracting the high-level attributes from AlexNet using the CNN. The license plates of six countries were employed to conduct the extensive experiments. The results demonstrated that recommended approach that real-time performance was ensured, and it performed better than the conventional and deep-learning technique.

Han Xiang, et.al (2019) suggested an effective lightweight FCN to detect the number plate from complex scenarios [63]. The network had downscaled the input images to considerably accelerate, proceed and reduce the evaluation cost. Dense connections and dilated convolutions were utilized to integrate the multilevel and multi-scale vision attributes. A fusion loss structure was attached to carry out training for enhancing the predictive exactness. A dataset in which 3977 images were taken in various scenarios from a range of circumstances had carried out to compute performance and widely utilized the Caltech LP data set. The simulation outcomes demonstrated that the presented technique was performed better as compared to various existing techniques and a good trade-off was obtained between high precision and computational costs.

Meeras Salman Al-Shemarry, et.al (2018) emphasized on developing a novel detection technique to recognize the vehicle LPs in low quality images through image processing methods [64]. A robust technique was implemented in which enormous AdaBoost cascades was executed with 3L-LBPs classifier for detecting the LPs regions. A higher accuracy was obtained using this technique to detect the LP number from one vehicle image. The images from 630 and 400 vehicles had utilized for testing and training the suggested technique. The images had comprised various difficult conditions. The outcomes of experiment represented that the suggested technique provided very satisfactory performance to detect the LP with respect to the speed and accuracy and performed effectively in comparison with a number of the existing techniques. The processing time to perform the entire testing number Plate Detection system was

computed as 1.63 sec. to 2 sec. The overall probability detection was computed as 98.56%, precision was computed as 95.9% and f-measurement was 97.19%, the false positive rate was evaluated as 5.6%.

Runmin Wang, et.al (2014) recommended a LPD technique designed on the basis of gradient information and a cascade detection framework [65]. There were 3 major modules comprised in this technique. Initially, a variety of Chinese license plate was taken in account for obtaining the gradient images so that the plate forms had integrated using image pre-processing. The cascade AdaBoost dataset had implemented in order to detect the NP in the next phase. At last, the candidate license plates were verified using various heuristic judgment strategies and a voting-based technique. The experimental study proved that the recommended technique was efficient for detecting the license plate.

Samiul Azam, et.al (2016) suggested a novel ALPD technique that assisted in detecting the LP region from an image in the unsafe circumstances in efficient way [66]. The rain removal was performed using a new technique in which frequency domain mask was carried out for filtering the rain streaks from an image. The suggested method established a novel contrast enhancement technique with a statistical binarization process to maintain the low contrast indoor, night, blurry and foggy images. The tilt correction technique based on Radon transform had implemented to correct the tilted LP initially. The non-LP regions were filtered using a novel condition on the basis of image entropy. There were 850 car images in which various hazardous conditions included employed for testing the suggested technique and provided the acceptable outcomes for detecting the license plate.

Manish Kumar Saini, et.al (2017) intended a framework implemented the localization concept of multiwavelet transform and EMD for locating the licence plate from vehicle [67]. An image was decomposed using Multiwavelet. The actual wave crest was discovered from the projected information which was obtained from multiwavelet transform with the help of EMD. The pre-processing and post-processing phases that had image enhancement and skew correction were carried out for acquiring the efficiency of intended algorithm. The single as well as double-line number plate was employed for testing the intended algorithm. The testing of performance of intended framework has been done through LPs of several countries under different conditions.

This algorithm was capable to detect the number plate with respect to higher accuracy and in relatively less time.

Vladimir Tadic, et.al (2016) designed a new algorithm for detecting and extracting the license plates from a complex image for which a fuzzy 2-D Gabor filter [68]. The filter parameters were fuzzified for optimizing the Gabor filter. The orientation and wavelengths of the Gabor filter had fuzzified particularly. Fuzzification of the wavelength had provided a greater selectivity. The filtering outcomes were obtained from these parameters. Bell's function and triangular membership function had demonstrated as the effective technique to choose the filter parameters in the experiments. The adequate outcomes were obtained using these filters. The extraction of components of interest was done and the procedure was discovered as very noise-resistant.

Zhenjie Yao, et.al (2014) Devised multistage information fusion-based License Plate (LP) detection method [69]. The new model included three stages of AdaBoost detector, a color checking module and Support Vector Machine detector. This method was aimed to decrease high false alarm rate. The new method performed better than the classic Adaboost detector during ROC curve. The new detector obtained Area Under Curve up to 0.9081. This demonstrated that improvement on feature extraction and multistage information fusion improved the efficiency for detecting the license plate in significant manner.

CHAPTER 3

PROPOSED VOTING CLASSIFICATION MODEL

3.1. Problem Formulation

Every country across the globe faces several problems related to movement. Extreme incorporation of data originations into every aspect of modern lifestyle has developed interest for handling automobiles as reasonable resource in data frameworks. It was required to adopt truthful data of vehicles due to the uselessness of steady data. In order to carry out this task, there is the need of either a human operator or a unique canny gear. The canny gear should be able to distinguish automobiles based on license plates and reproduce it into implemented resources. In this regard, a number of detection approaches have been devised over the time. In current era, the LPR systems act as a component of various operations and safety measures like fringe handling or tracking of lost automobiles. Neural systems are used in every LPR framework developed so far. This study presents a new faster and more competent LPR framework by employing Gabor channel, OCR and computer vision.

3.2. Objectives

The objectives to be served by this research are:

1. To Study and analyse various car number plate detection techniques

2. To propose novel approach for detection based on voting classification

3.Implement proposed approach and compare with existing in terms of certain parameters.

3.3. Research Methodology

The intend of this work is the detection of license number plate. There are many stages included in this process such as pre-processing, feature extraction, region of interest and classification. This work extracts texture features by applying GLCM algorithmic approach. This algorithm takes out approximately 13 attributes from the picture applied as input. In the course of region of interest selection whole image will be converted to binary image which later processed to calculate radius of the area. The portion which has maximum area will be defined as the region of interest. The next step is based on the number plate recognition. The license number plate detection is based on the morphological operations. The input image will be converted to gray scale which will be further processed for the filtering. The operation of dilation and erosion will be applied for the hue correction. The operation of masking will be applied which will mark the number plate portion. In the license number plate verification process, the features which are extracted will be used for the training. The technique of voting classifier will be applied for the number plate verification. The random forest and SVM algorithms will be used for the voting process to verify the number plate. RF is an ensemble learning algorithm. This basic principle of the algorithm is that a small DT is developed with few attributes is a computationally cheap procedure. When various small, weak DTs are developed in parallel, the trees are integrated for forming a single, strong learner after averaging or obtaining the majority vote. The RFs are often investigated as the most accurate learning algorithms to date in training.

Formally, a RF is a predictor in which a collection of randomized base regression trees are comprised as $\{r_n(x,\ominus_m, D_n), m \geq 1\}, where\ \ominus_1,\ominus_2$ .... are independent and identically distributed outputs of a randomized variable $\ominus$. These integration of RTs is done for developing the aggregated regression estimate

$$\bar{r}_n(X, D_n) = \mathbb{E}_{\ominus}[r_n(X,\ominus, D_n)],$$

In which $\mathbb{E}_{\ominus}$ represents the expectation in terms of the random parameter, conditionally on X and the data set D_n. In the following, to lessen a notation a little, the dependency of the estimates would be excluded in the sample, and written to illustrate $\bar{r}_n(X)$ rather than $\bar{r}_n(X, D_n)$. In practice, Monte Carlo computed the above expectation when the M RTs are produced, and the average of the individual outcomes is taken. The

randomizing variable $\ominus$ is carried out for determining performance of the successive cuts while developing the individual trees in which selection of the coordinate to split and position of the split are comprised. The variable $\ominus$ is deduced as the independent of X and the training sample D_n.

SVM is a supervised learning technique which was utilized to perform classification and regression. The performance of high generalization is obtained from it. The addition of prior knowledge is not essential in it even in the case of high availability of input space size. In this way, it becomes a approach with better features. The key objective of this classification system is to separate the objects of a couple of classes in data used for training. For this purpose, the best classification function is discovered. It is a generalized linear classification scheme. The SVM is implemented to increase the geometric margin and to reduce the errors during classification at the same time [14]. It generates the separating hyperplane that assisted in maximizing the margin between two data sets. To achieve this, input data is regarded as dual groups of vectors within n dimensional space. The formation of two parallel hyperplanes is done for the computation of the margin, one on either side of hyperplane being separated. The fine separation is obtained with the maximal distance to the neighbouring data points included in every class. The generalization error will become least when the margin is huge. Therefore, the hyperplanes is discovered using the support vectors and margins. In this, the data instances are present as:

$$(Z_1, X_1), (Z_2, X_2), (Z_3, X_3), (Z_4, X_4), \dots \dots \dots (Z_i, X_i)\}$$

Here, $Z_i = 1/-1$ refers to a constant. This is utilized to represents the class of zi. The variable i illustrates the number of samples. The m-dimensional real vector is denoted with zi. The separating hyperplane is used to view the training data in easy way that is represented as

$$u.z + c = 0$$

In this u and c denotes m-dimensional vector and scalar respectively.

The vector u is vertical to the separating hyperplane and the margin is maximized with the scalar parameter c. If the c is not available, the hyperplane goes through (0,0)

forcefully. There is a necessity of parallel hyper-planes for the maximization of the margin. The following equation defines these parallel hyper-planes.

$$u.z + c = 1$$

$$u.z + c = -1$$

The parallel hyperplanes are selected because no points occur amid them in case of separation of training data in linear way. The 2/|u| is obtained as the distance among the hyper planes in geometrical manner. For this, the reduced |u| is required. The equation is defined as:

$$u.z_j - c \geq 1 \; or u.z_j - c < -1$$

A hyperplane can be properly defined using the expression:

$$\mathrm{F}L(z) = \alpha_o + \alpha^c z$$

In which α and $\alpha_o$represents vector and the bias respectively.

The scaling of α and $\alpha_o$is utilized to denote the optimal hyper-plane. The selection of one representation is done from dissimilar possible representations of hyperplane which is defined as:

$$|\alpha_o + \alpha^c z| = 1$$

Where z is used to denote the training points nearest to hyperplane and they are called SVs (Support Vectors).

3.4. Proposed Methodology

The following flow chart provides a brief overview of the research methodology proposed in the present work

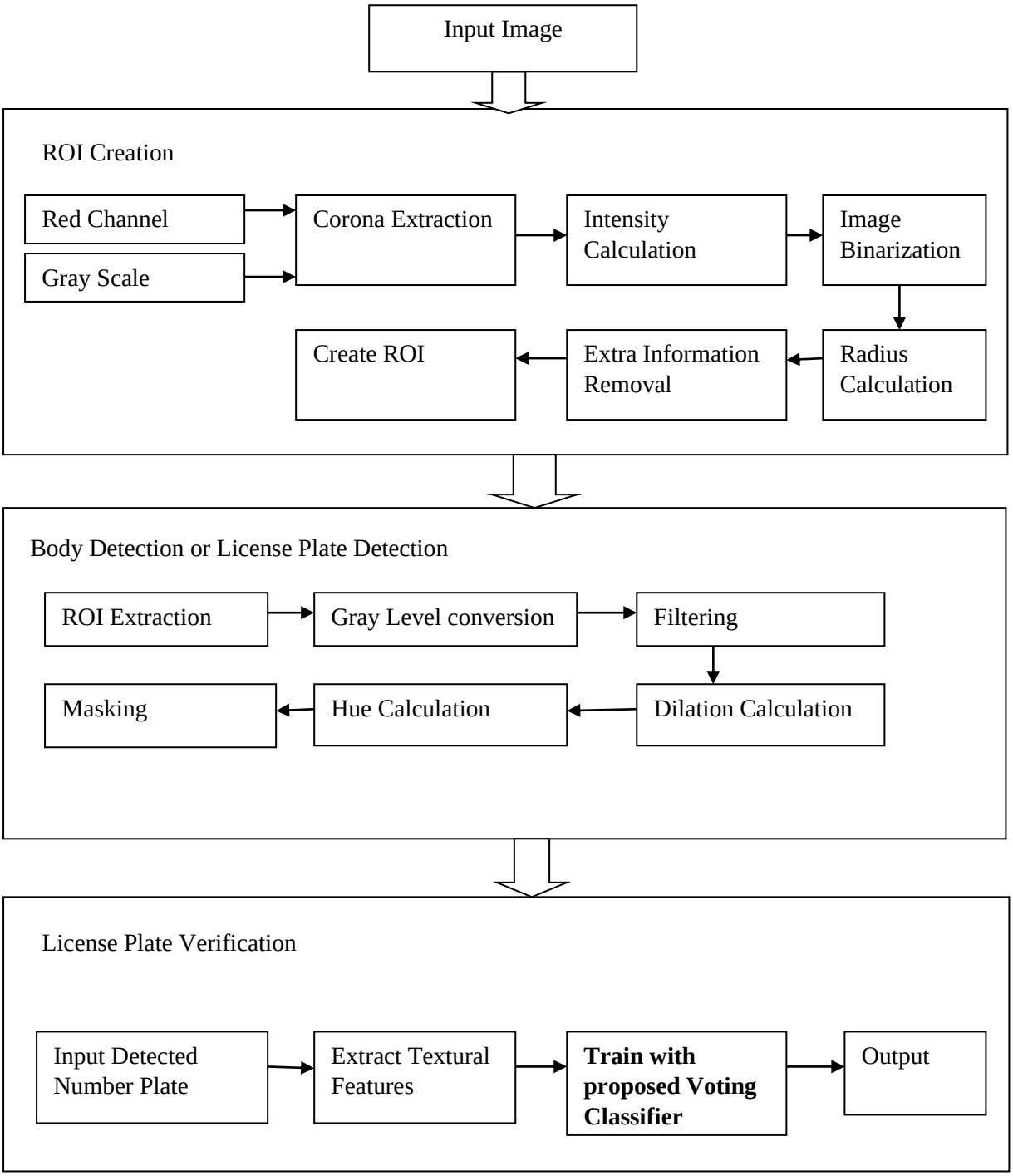

Figure 3.1 Flow Chart of Proposed Methodology

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Dataset Description

A dataset in which images of license plate are comprised has employed for detecting number plate with the implementation of computer vision. The clean and annotated datasets are offered by some research groups. But many datasets are small in size. Any object detection architecture such as YOLO or SSD utilizes these datasets in availability of the bounding boxes. But a work is required for reformatting the dataset. The video of cars which are entered in the UCSD campus from the Gilman entry at different times in a day has recorded about ten hours in account. But there are frames which have taken from video footages captured manually using model info, positions and texts of number plate. The snapshot of the license plates of around 878 cars is captured frame by frame. A digital camera is deployed to capture the pictures of 291 cars in parking lots. The password is used on files for their protection. There are 900 of cars which are containing gray License plate; 300 of cars having red License Plate; 300 of motorcycles having gray LP. The dataset is liberated for the academic research only and there is without any charge to researchers who belongs to educational or research institutes for non-commercial purposes.

Fig 4.1 Interface of the code

Figure 4.1 depicts the interface that distinguishes the license plate from the rest of the car structure. This interface have three buttons, the fist button is of car number plate detection/recognition, second button is of body detection and last button is of parameter analysis. This provides and simple and clean GUI to workaround which can be customized accordingly as per the user need.

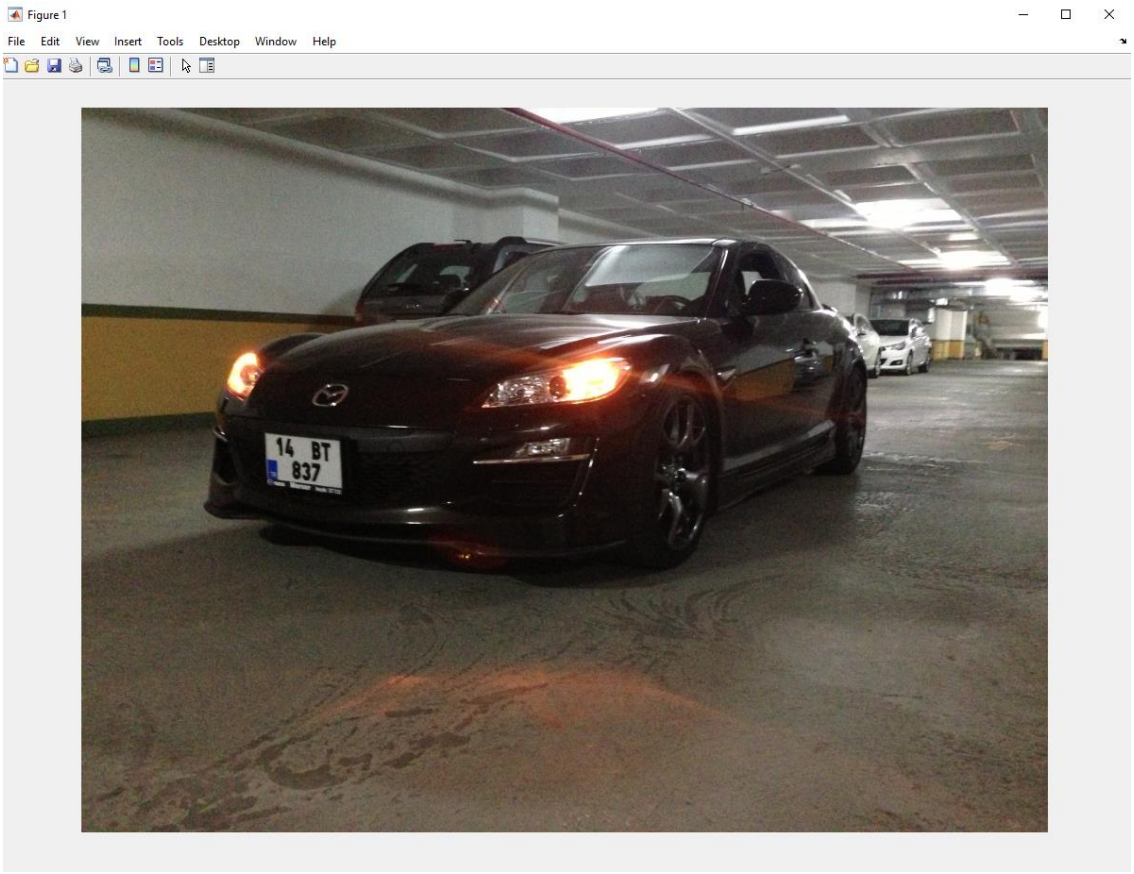

Fig 4.2 Car input for number plate detection

Figure 4.2 depicts the interface that distinguishes the license plate from the rest of the car structure.The picture used here contributes in the recognition of license plate. A black color vehicle is taken for the experimental purpose. Further, with the dim background to check for the recognition capability of the proposed model.

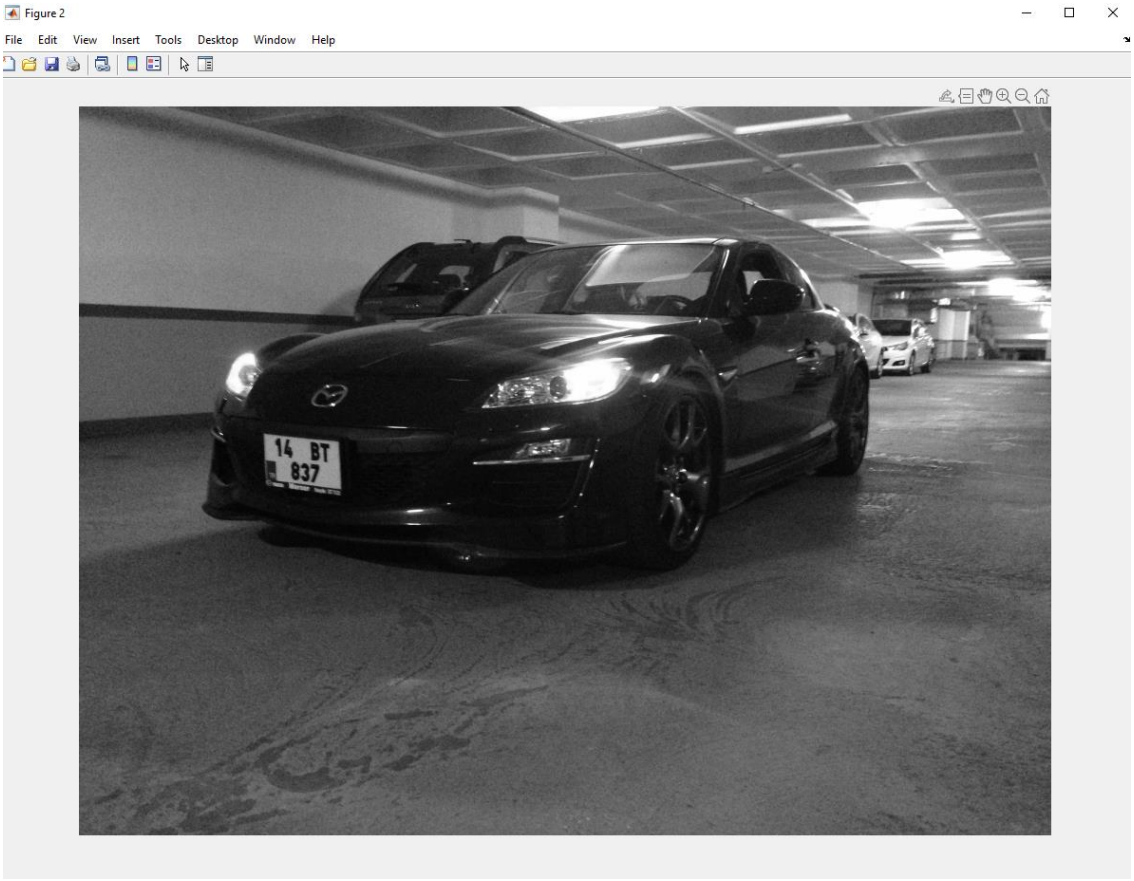

Fig 4.3 Gray Scale Conversion

Figure 4.3 depicts the interface that distinguishes the license plate from the rest of the car structure.The picture used here contributes in the recognition of license plate. For highlighting number plate, the picture of car is switched into dim scale.

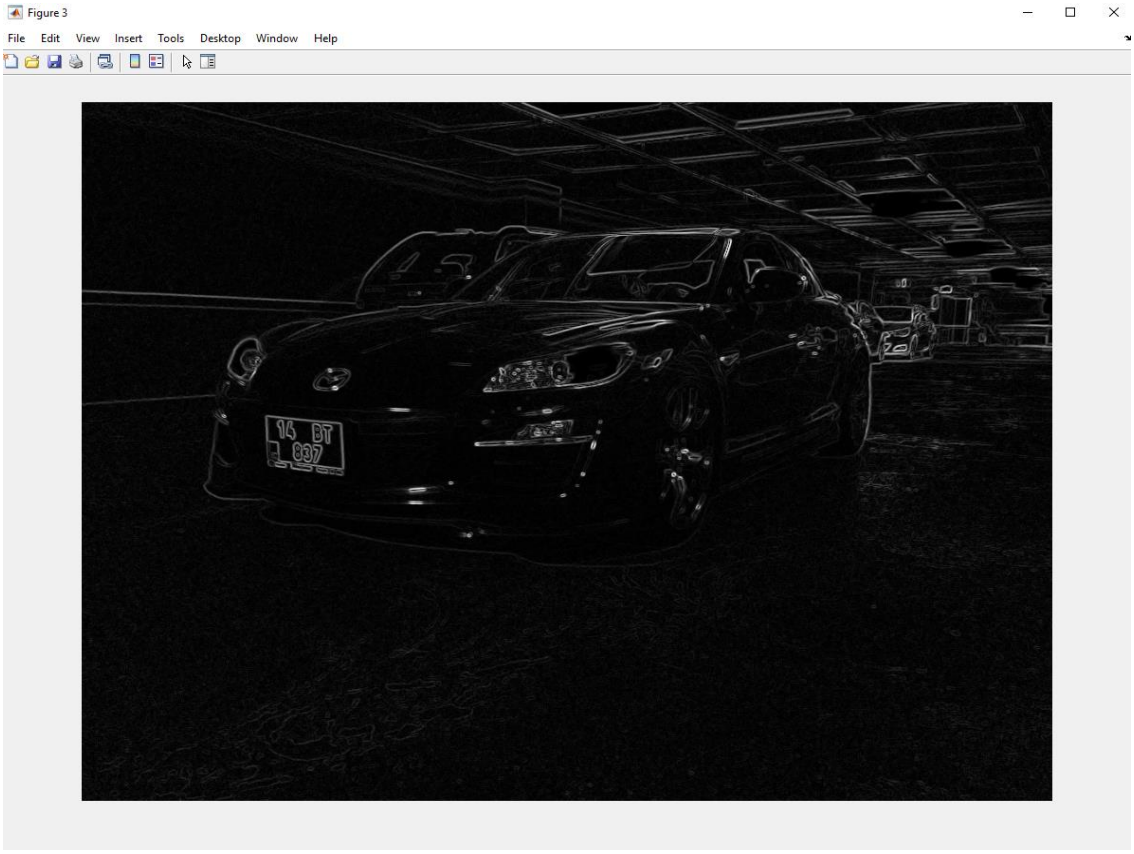

Fig. 4.4 Edge Detection

Figure 4.4 depicts that the flow is doing the edge detection using Sobel edge detecion operator as one of the many intermediate steps to clearly demarcate the region of interest and the body of the vehicle, to effectively use the image for filtering and further morphological operation.

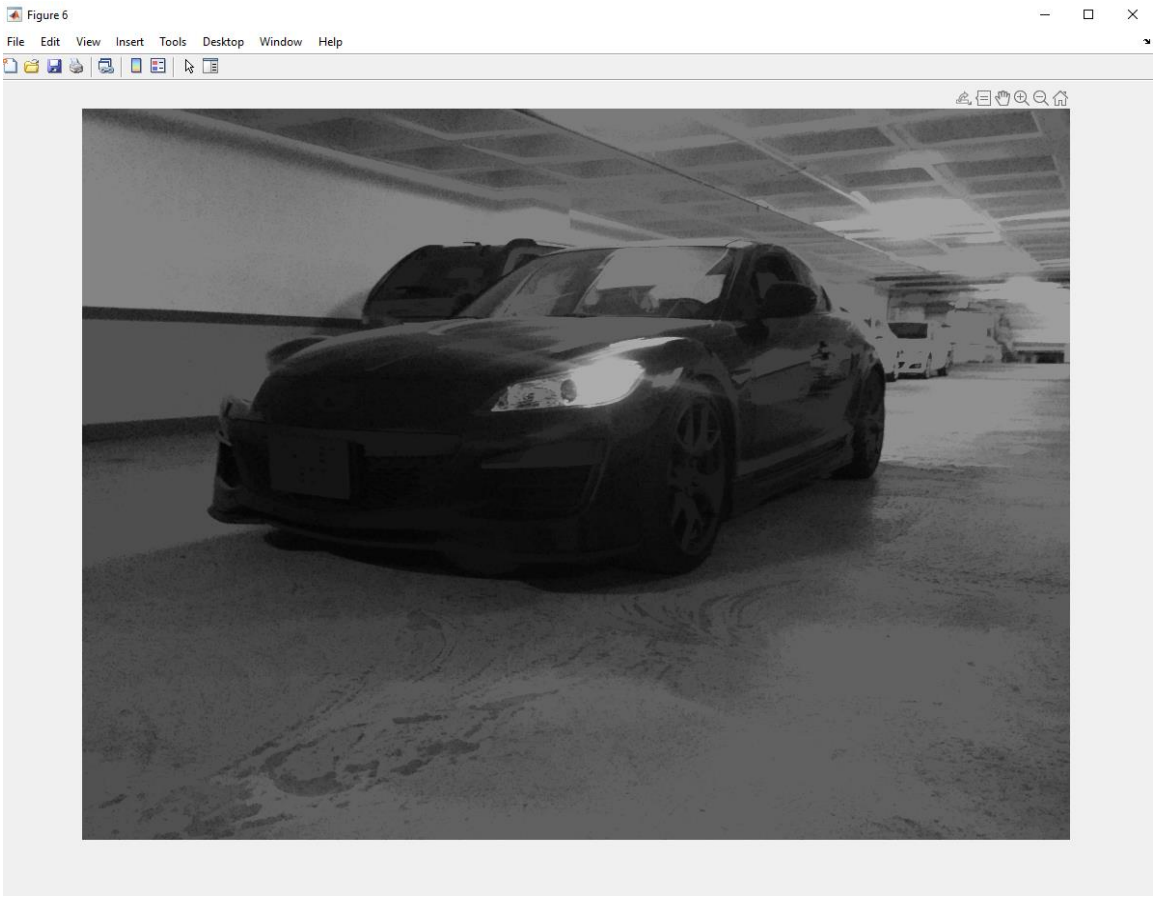

Fig. 4.5 Filtering

In figure 4.5 we have utilized the iterative Bi-lateral filtering to remove noie. Iterative bilateral filter is a kind of non-linear filter. Contarty to median filter, it provides better results in case of supression of noiseand maintains edges as well. This filtering approach redcudes the effect of bluriness and provides smoother picture.

The picture redeveloped with bi-lateral filtering approach is higher in PSNR (Peak Signal to Noise Ratio) value than the images redeveloped by other filters. Thus, the picture filtered by iterative bilateral filter is of superior quality than its counterpart developed by other filtering approaches.

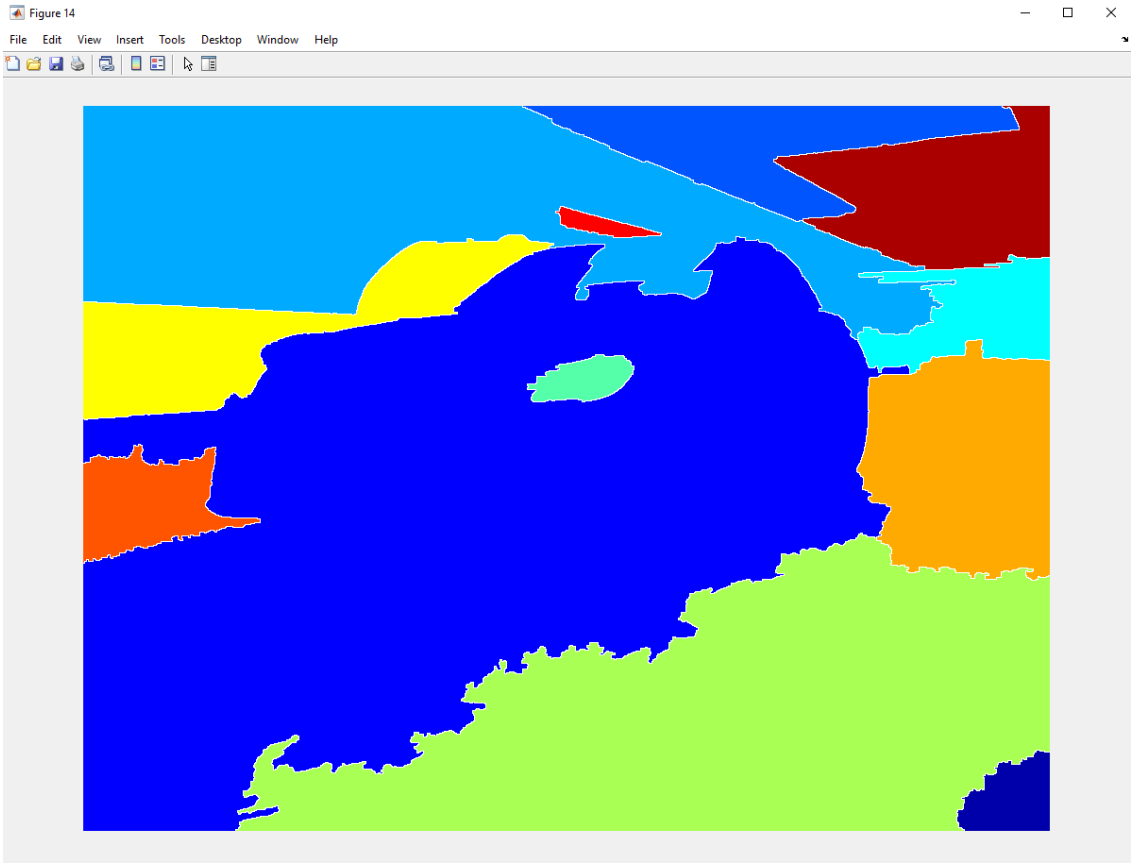

Fig. 4.6 Hue Calculation

Figure 4.6 depicts the image that is being generated in between the body detection process to calculate color appearance parameters. This parameter generally yields as a single digit number. It is possible to define a stimulus alike or differ from stimuli known as purple, red, yellow, blue, orange, green.

It relates to an angular position beside a centralized or neutral point on a color space coordinated figure or a wheel of shades, or by its leading wavelength or that of its corresponding shade. The color presence metrics are saturation colorfulness, contrast and intensity. Furthermore, shades having the similar hue are differentiated w.r.t to relatable hue in accordance with their lightness or colorfulness.

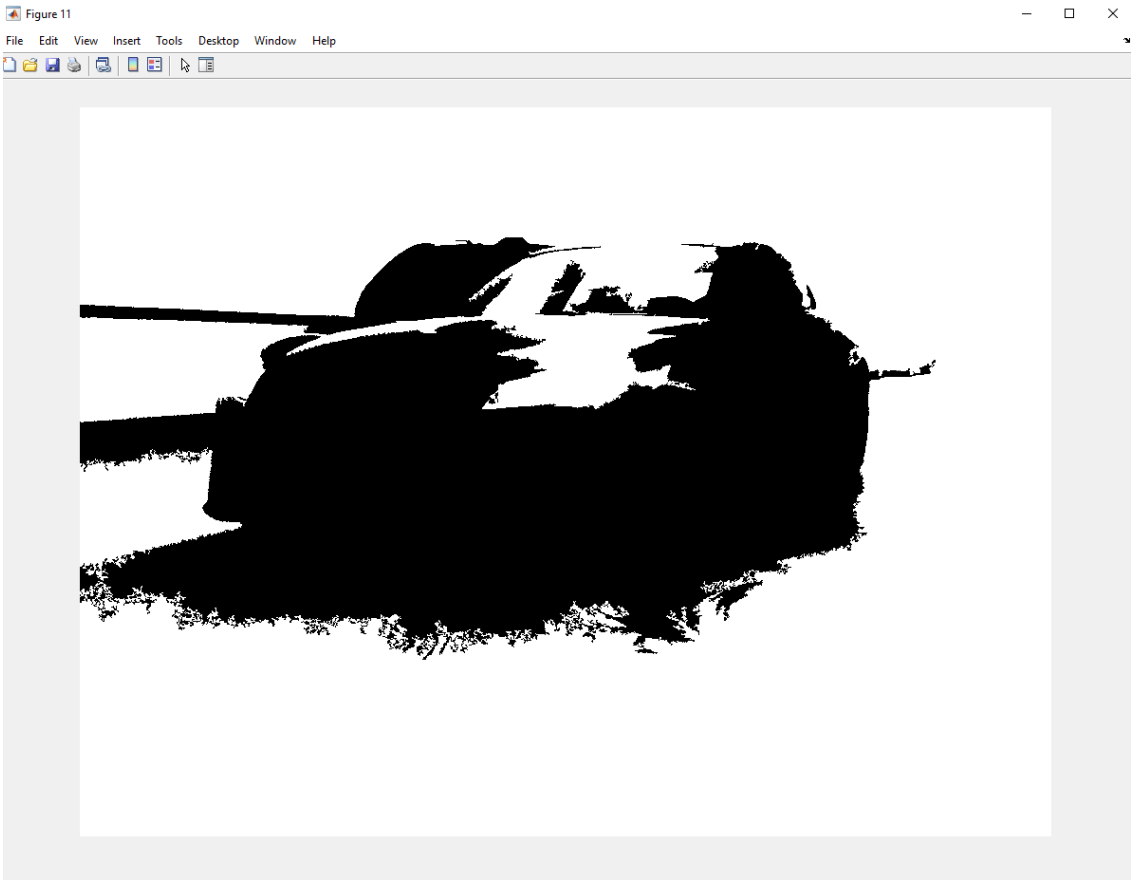

Fig. 4.7 Dilation Calculation

In figure 4.7, the number plate area and the vehicle body is identified accurately. In the first step the dilation calculation is performed on sobel edge detected number plate. Further, the filling of holes is performed in the resultant picture. Furthermore, the unwanted or extra portion of image is eroded with opening process. Moreover, the number plate area is identified by applying erosion process. Additionally, the final results of implementing dilation operation and filling holes is to intensify the Region of Interest extraction to efficiently identify the number plate.

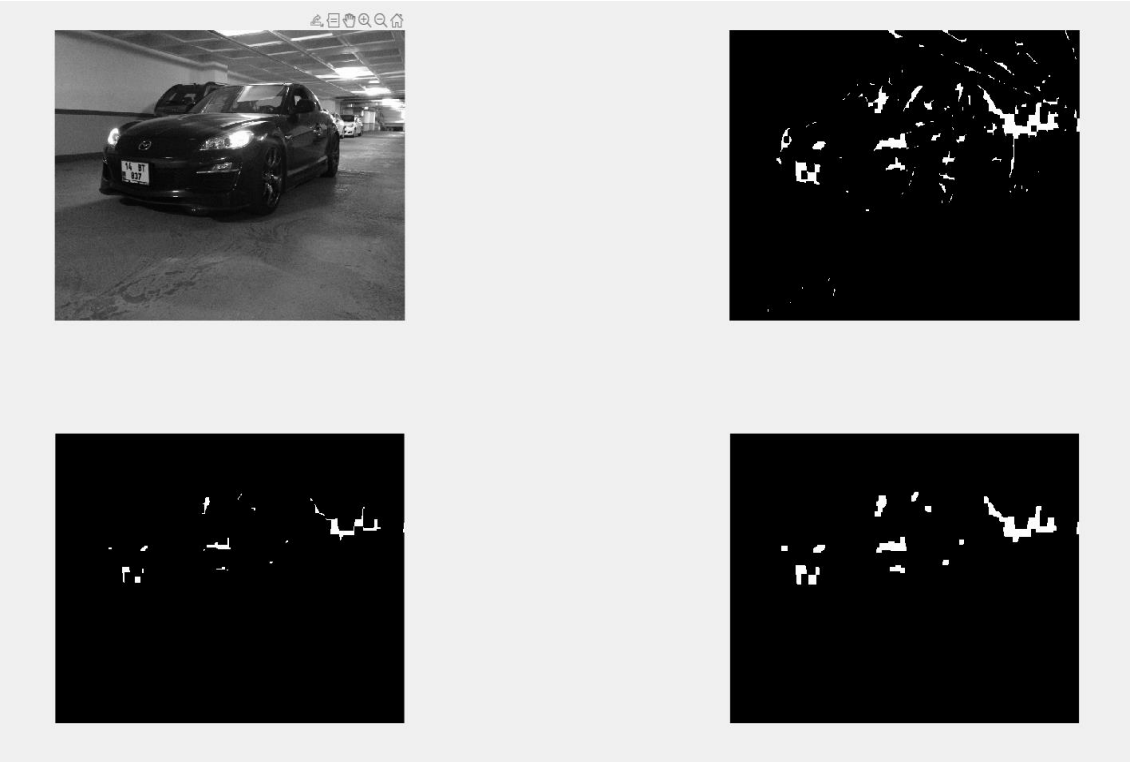

Fig 4.8 Slicing of Car image

Figure 4.8 shows an interface intended for detecting licence plate as well as the car structure. This task is accomplished by applying a car image as input. The conversion of car image is carried out in Gray scale for making the detection of license plate possible. The converted image is further sliced into a number of portions, with every portion to be dealt with separately. The main reason behind implementing slicing is to recognize the desired areas from the input image.

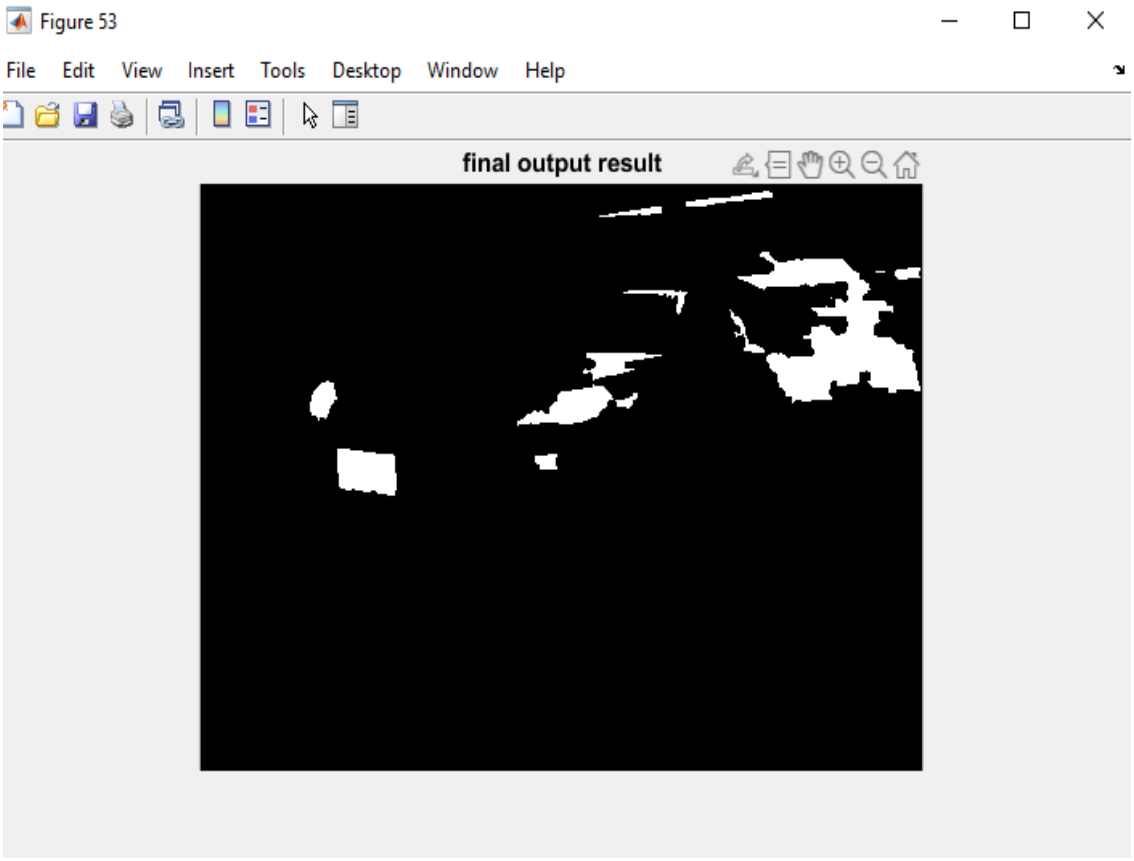

Fig.4.9 Masking

Fig. 4.9 shows the masking of the vehicle and further keeping the region of interest intact in the front of the bumper of the vehicle. Region of Interest that was created with the help of image binarization followed by the extraneous information removal is now being clearly distinguished from the rest of the portion of the image. Prior to all these steps we have achieved the Image binarization was achieved after the gray scale conversion.

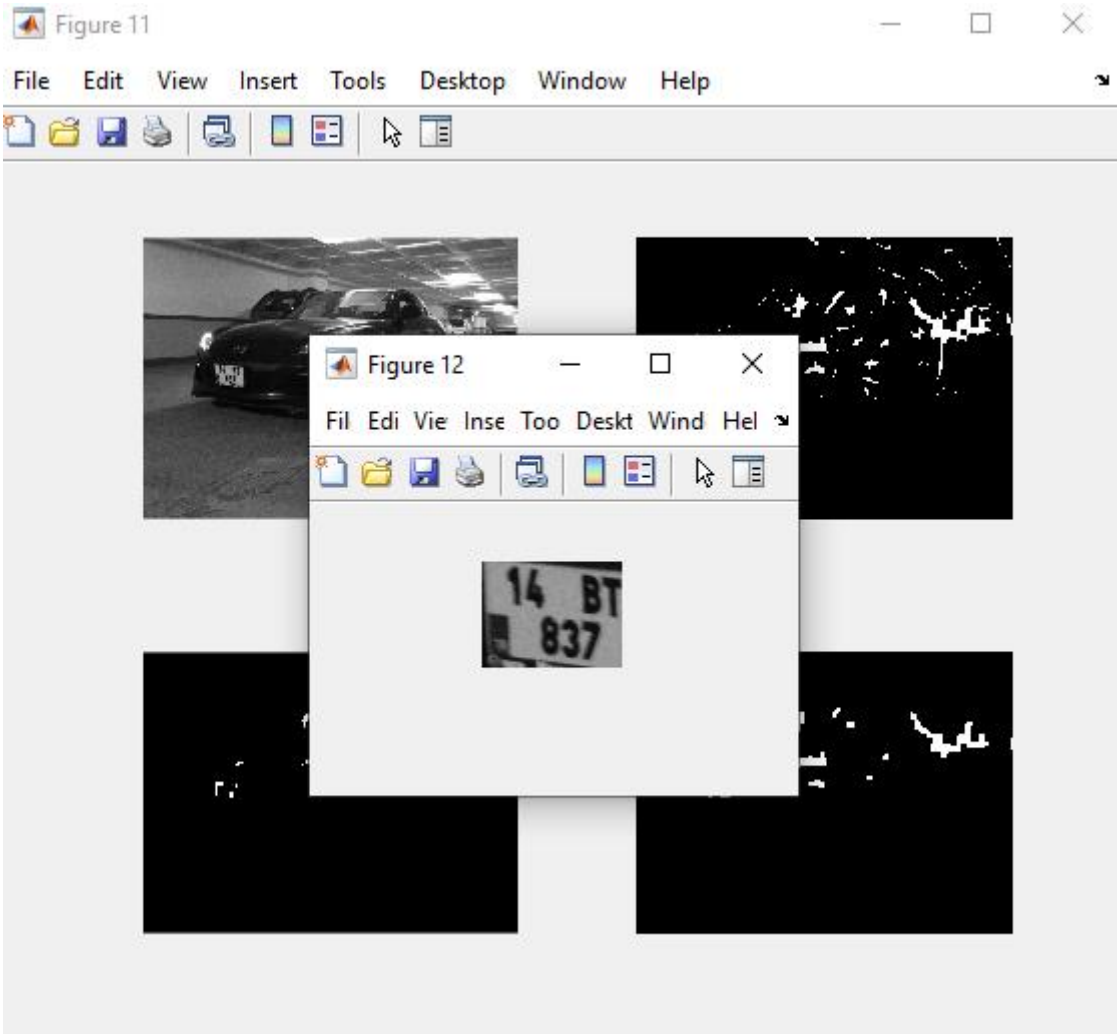

Fig 4.10 Detection of Number plate

Figure 4.10 shows an interface intended for detecting licence plate as well as the car structure. This task is accomplished by applying a car image as input. The conversion of car picture is carried out into gray scale to make license plate visible. The dark scale image is sliced into many portions and each portion will be treated separately. The technique of voting classifier will be applied which will verify the number plate

Fig. 4.11: Sample Image 1

Fig. 4.12: Sample Image 2

Fig. 4.13: Sample Image 3

Fig 4.14: Sample Image 4

Table I: Accuracy Analysis

Image Number	KNN Classification	SVM Classification	Voting Classification
Image 1	83.89 percent	86.5 percent	92.45 percent
Image 2	80.34 percent	85.89 percent	93.45 percent
Image 3	86.67 percent	87.78 percent	94.65 percent
Image 4	83.78 percent	86.68 percent	94.89 percent

Table II: Precision Analysis

Image Number	KNN Classification	SVM Classification	Voting Classification
Image 1	82.89 percent	86.53 percent	93.45 percent
Image 2	80.34 percent	86.70 percent	95.45 percent
Image 3	86.62 percent	88.89 percent	91.89 percent
Image 4	83.78 percent	82.86 percent	95.81 percent

Table III: Recall Analysis

Image Number	KNN Classification	SVM Classification	Voting Classification
Image 1	83.36 percent	86.5 percent	93.45 percent
Image 2	79.56 percent	85.89 percent	95.45 percent

Image 3	86.58 percent	86.77 percent	91.72 percent
Image 4	84.63 percent	85.86 percent	94.34 percent

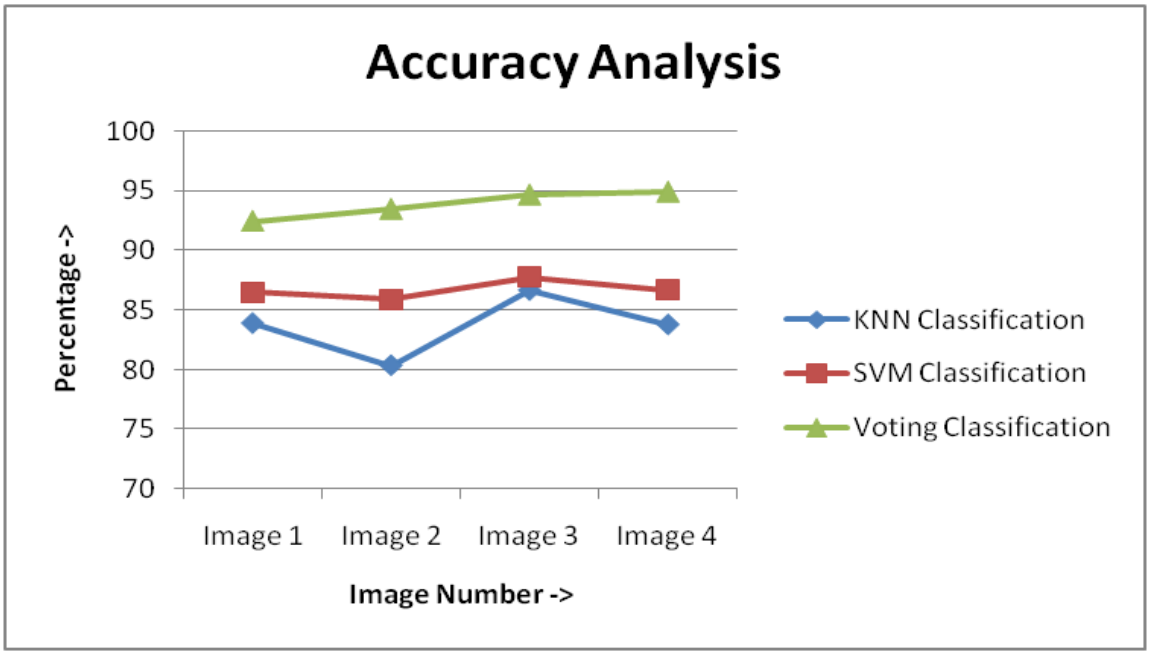

Figure 4.15: Accuracy Analysis

Figure 4.15 shows accuracy-based comparison between the KNN, SVM and the voting classifier. It is analysed that voting classifier have high accuracy which is raised to 95 percent in many of the cases. As, the accuracy analysis has very much dependency on the quality of the image taken and environment condition in case of running video. Thus, here Accuracy refers to the highest accuracy that we have achieved over a definite sample size.

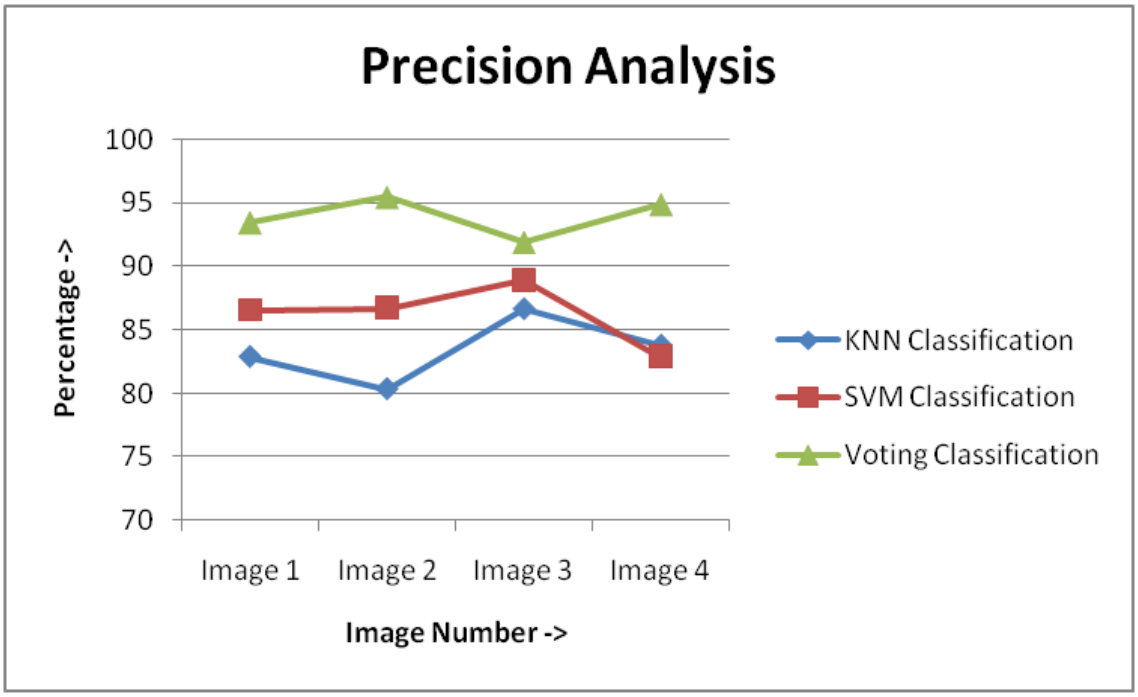

Figure 4.16: Precision Analysis

Figure 4.16 shows precision-based comparison between the KNN, SVM and the voting classifier. The obtained outcomes reveal that voting classifier has high precision value than that of other two approach. Precision analysis is however is directly related to the accuracy achieved. If a model is accurate in its classification, it definitely tends to be more precise.

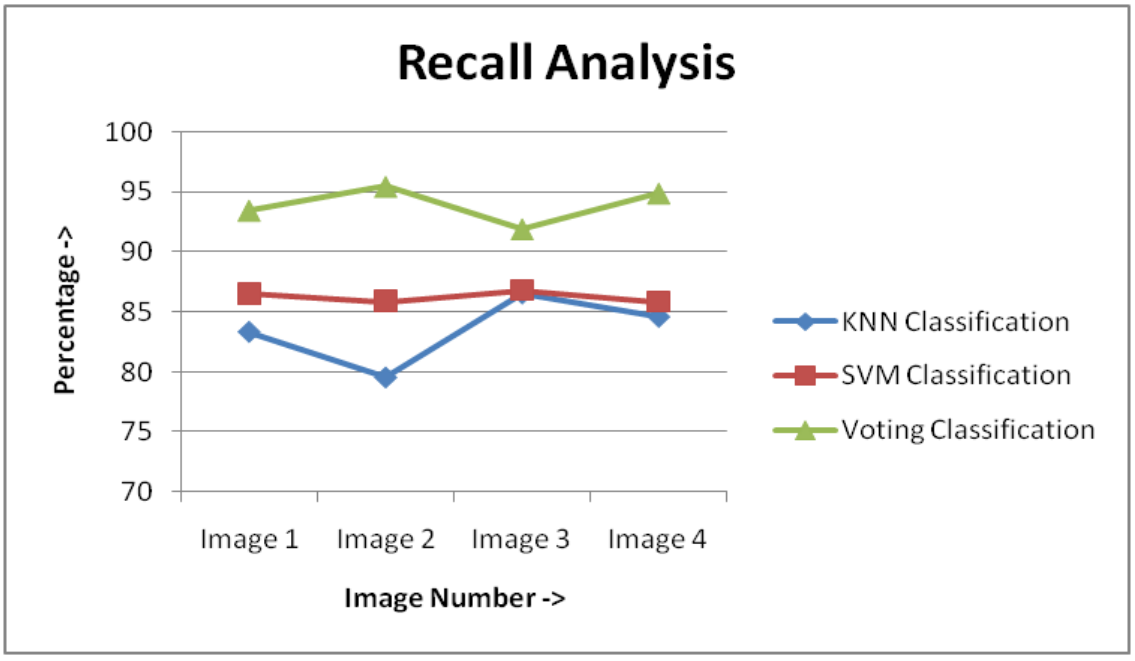

Figure 4.17: Recall Analysis

Figure 4.17 shows the recall-based comparison between voting, KNN and SVM classifier. As per analysis, voting classifier has high recall value as compared to the other two classifiers. Similar to the precision, the recall also dependent on the accuracy. Further, both the precision and the recall can be represented with a single number known as F-measure.

Table IV: Results Comparison

References	**Accuracy (%)**	**Precision (%)**	**Recall (%)**
Proposed Model	**94.89**	**95.81**	**95.45**
Muhammad Attique Khan [70]	87.78	88.89	86.77
Ana Riza F. Q et.al [71]	87.43	86.62	86.58

Table 4 presents comparative analysis of all the three parameters for the proposed model with that of other references using each of the different classifiers we took for comparison. The values mentioned in the table for each of the reference has been deduced and verified. The comparison suggests that the proposed model with voting classification yields a much better improvement in the accuracy, precision and recall as expected.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1. Conclusion

ANPR is an acronym for Automatic Number plate Recognition. This approach detects the number of vehicles by applying OCR on images. This approach can store images clicked by image capturing tools. The frameworks normally utilize infrared light and enables camera for clicking image irrespective of the lighting condition. A powerful flash is incorporated into no less than one adaptation of the crossing point observing cameras, that not only lights up the image but also keep an eye on offender. This system has a tendency to be area specific. A unique recognition strategy has been devised in this work. At present, the use of LPR systems for various movement and safety purposes is very common. Some popular examples include tracking of thieving vehicles, detection of invalid number plates etc. In this work, technique is proposed which is based on voting classification to detect far number plates. The proposed technique will improve accuracy, precision, recall and reduce execution time.

5.2. Future Work

Following are the various future possibilities of this work: -

1. The proposed algorithm can be further improved using transform learning technique

2. The proposed algorithm can be compared with other number of detection algorithms

APPENDIX I

List of Publications

List of Papers Accepted and Published:

A Low Power and High Speed 8-bit ALU Design using 17T Full Adder, 7th International Conference on Signal Processing and Integrated Networks (SPIN 2020) 27nd- 28th February 2020.

List of Papers Awaiting Acceptance:

Voting Classification Method for Vehicle Number Plate Detection, 17th IEEE India Council International Conference (INDICON 2020) 11th – 13th December 2020.

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