MANIPAL INSTITUTE OF TECHNOLOGY
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Vehicle License Plate Recognition

A Mini Project Report submitted to Manipal Institute of Technology in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

MECHATRONICS

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CERTIFICATE

This is to certify that the mini project titled **Vehicle License Plate Recognition** is a record of work done by **Nitin Medisetti(190929100)**, **Juvvi Manas Sashank (190929242)**, **Bhanu Prasad A J (190929106)**, **D Sai Shreyas (190929238)**, submitted for Machine Vision and Image Processing (PE-V), MTE 4075 during the academic year 2022-2023.

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Abstract:

Personal transport has become an essential part of the modern household. India having the world's 3rd largest road network is especially one of the most growing car markets. It is estimated that there are about 22 cars for every 1000 people in India. Although the increase in the car population is looked at favorably, it comes hand in hand with the increase in the scale of problems that already plague the current car owners and their communities.

Issues such as parking, security, etc. which have already been causing trouble for the existing owners are intensifying with the increase in the car numbers. All the vehicles are regulated through their unique registration. Tracking cars can easily be performed by taking note of the car's registration number. This poses to be a convenient way for tracking or surveillance of unknown vehicles by just noting down the registration number of the car. It is also quite normal to see toll booths on highways or at state borders that record the registered numbers of the cars. There are more than 1000 toll booths just on the state borders of our country.

The process of recording the registration number of cars is a dull, diligent, and boring task. Yet, this mechanical job is heavily delegated to human workers. Implementing autonomous recording of the registration numbers can cut down the cost, eliminate human error, and most importantly, allows us to reallocate precious human resources to somewhere it is of bigger importance.

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Chapter 1

Introduction

1.1 Motivation

Our approach toward the detection, localization, and extraction of the registration number from a static RGB image was heavily inspired by a set of other research papers. Each of the research papers suggested a set of operations that performed well in certain aspects. We tested a combination of different algorithms and identified a particular combination that worked best in most cases.

1.2 Objective

The objective of this project is to output the registration number of the subject vehicle when an input image is provided. The program aims to detect, localize and segment the number plate, thus differentiating itself from the background and extracting the registration number from it. The program also includes a series of pre-processing operations to enable the program to operate even in low-light conditions with reasonable success rates even in low illumination.

1.3 Challenges

The critical challenges of this problem statement are

1. Localization of the license plate from the input image
2. Wear and tear of license plates which may make them hard to be recognized
3. Noisy images and low light

1.4 Report Organization

This Report is organized into six chapters, mainly including an introduction, literature review, methodology, result and discussion, conclusion, and future scope and contribution of each team member. Each chapter is supported with relevant subtopics.

- Chapter 1: Includes the overview of the report. The objectives, along with a problem statement, hypothesis, and scope of research, are stated in this chapter. It tries to focus on the need for research and the methodology used for problem analysis.

- Chapter 2: Literature reviews of methods are discussed. A brief review of the problem statement is taken into consideration. A summary is presented that highlights the research gap.

- Chapter 3: Addresses the methodology used in this report. Presents the flow diagram of the proposed method. Details of the dataset used is presented in this chapter. Justifies the method utilized for the getting solution to the problem. A detailed description of the method of work is presented.
- Chapter 5: Discuss the result and their detailed discussion that is obtained by applying the proposed methodology from the data analysis and simulation.
- Chapter 6: Presents the conclusion and scope of future work.

Chapter 2

Literature Review

2.1 Review of the Literature

In the base paper, the author(s) made use of an interesting operation that enabled them to smoothen out just the edges of the image. They did this by performing something known as a top-hat filter. This operation involves performing an opening morphological operation on the image and subtracting it from the original image . Since their method for localizing the number plate required them to segment the image using contours, this operation resulted in a significant increase in the accuracy of the localizing module.

The auxiliary paper discussed a unique way to perform image enhancement. Image enhancement is a method to highlight the features in the image, which are of significant importance to the performance of the Number-Plate reading program. The auxiliary paper suggested performing image enhancement using the negative of a given image. The negative of the RGB image is first taken and stored. The stored image is then operated on by a set of different operators to perform the “de-hazing” operation. The operated image is then reverted back to color, thus resulting in an enhanced color image.

2.2 Summary

Both papers provided us with unique and effective methods to increase the accuracy of the program in different ways. One of them provided us with an efficient algorithm to improve our localizing module, whereas the other enhanced the image thus making the extraction process significantly easier. The algorithms from the above papers along with a few minor tweaks suggested by some other related support papers are without a doubt, the cornerstone of the program.

Chapter 3

Methodology

3.1 Theoretical Background

The proposed methodology consists of the following phases: Pre-processing for license plate detection, License plate detection, Pre-processing for license plate recognition, License plate recognition, and Authentication, as shown in the figure below.

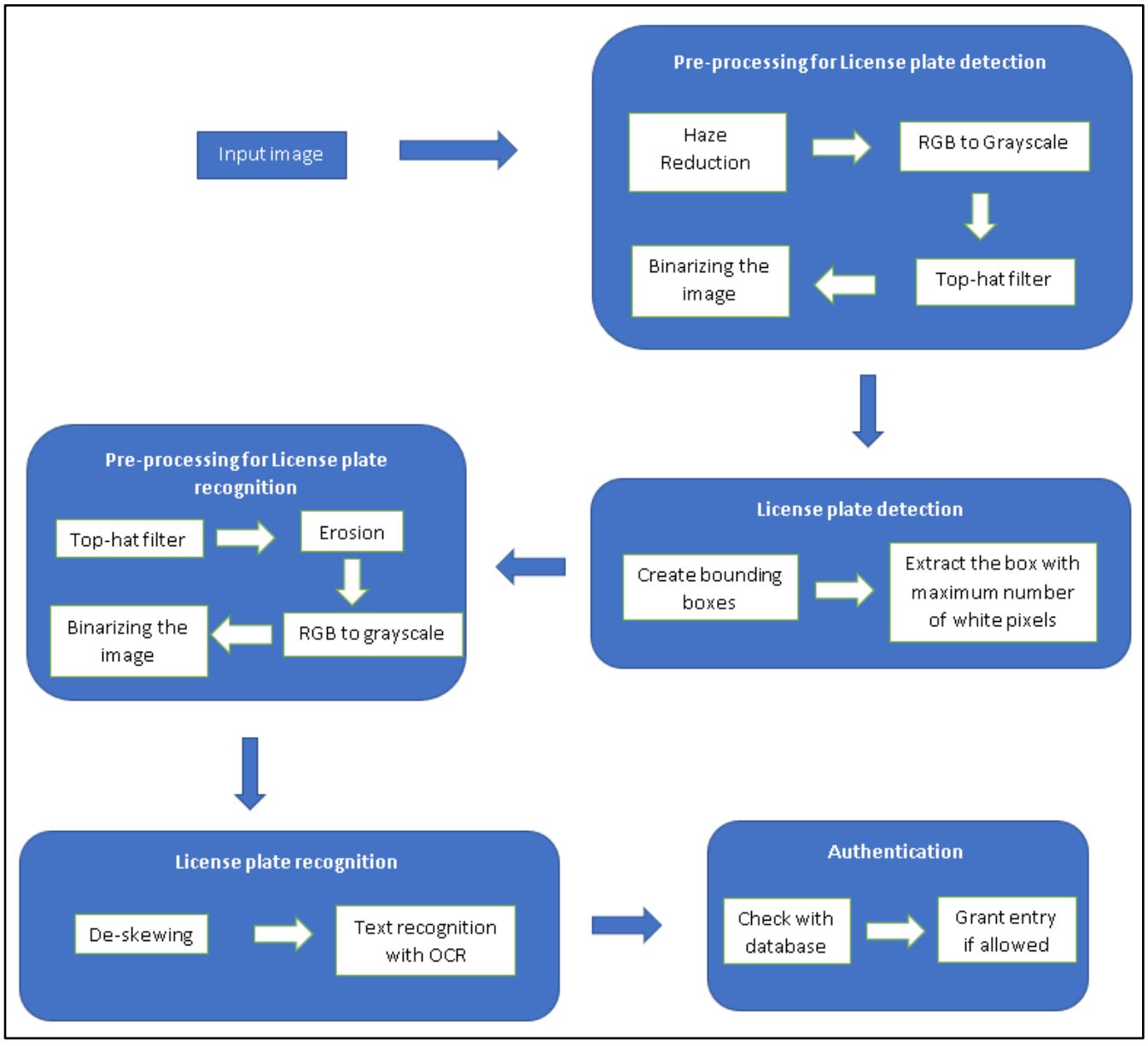

Figure 1, Flow chart

3.1.1 Haze Reduction

The RGB image is complemented, then the haze present in the low light regions in the image is reduced. The resultant image after inverting it back is enhanced.

Figure 2, Haze reduced image

3.1.2 Top hat Filter

Top hat filtering is computing the morphological opening of the image and subtracting it from the original image. It is used to segment the images into different regions and to remove uneven background illumination from an image with a dark background.

Figure 3, top-hat filtered image

3.1.3 Binarization

Image Binarization is the conversion of a document image into a bi-level document image. Image pixels are separated into dual collections of pixels, i.e., black and white. The main goal of image binarization is the segmentation of the document into foreground text, and background

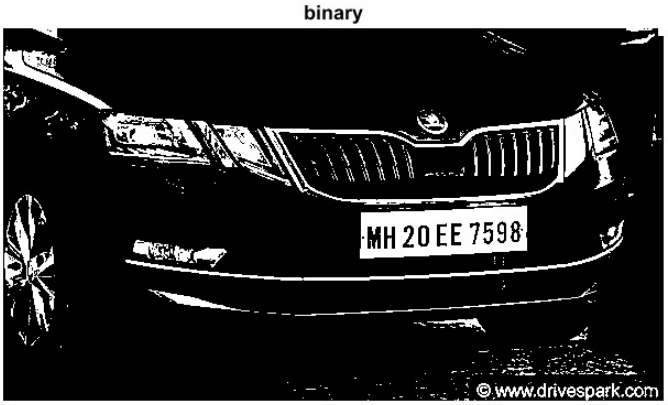

Figure 4, binarized image

3.1.4 Localization

For segmentation regionprops function has been used. It returns measurements for all 8-connected components in a binary image and groups them as rectangles(bounding boxes).

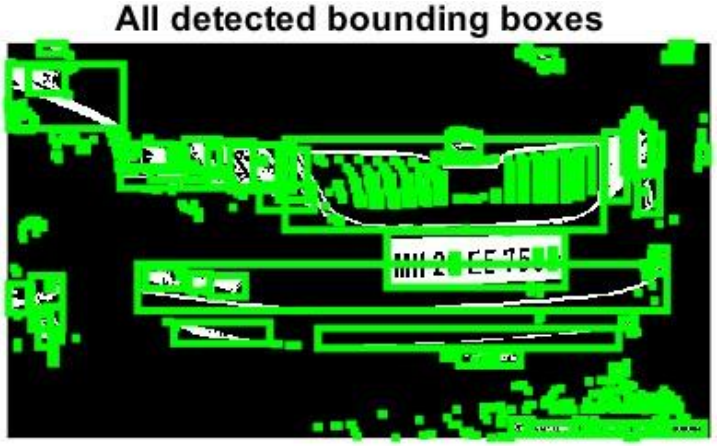

Figure 5, all detected bounding boxes

Then we choose the box with maximum number of white pixels from the binary image. This box can be extracted to get a localized image of the license plate

Figure 6, bounding box with max. no. of white pixels

3.1.5 Deskewing

A process whereby skew (slant) is removed by rotating an image by the same amount as its skew but in the opposite direction.
Hough Transform: It is a feature extraction technique that converts an image from Cartesian to polar coordinates. It can be used to detect lines or a set of collinear points on the image.
Steps

1. Apple Canny filter on a gray scaled image.
2. Find Hough lines between 0.1-to-180-degree angle.
3. Round the angles from line peaks to 2 decimal places.
4. Find the angle with the highest occurrence.
5. Rotate the image with that angle

Figure 7, Skewed Image

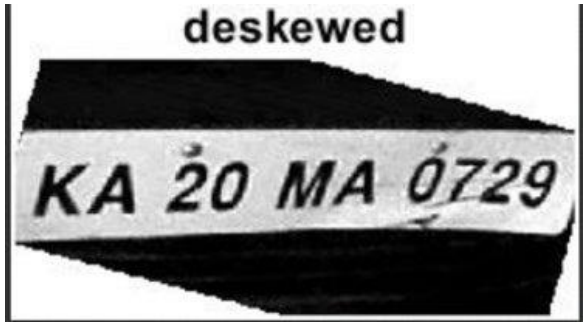

Figure 8, Deskewed Image

3.1.6 Optical Character Recognition

Optical Character Recognition, is a process of recognizing text inside images and converting it into an electronic form. These images could be of handwritten text, printed text like documents, receipts, name cards, etc., or even a natural scene photograph. OCR has two parts to it. The first part is text detection where the textual part within the image is determined. This localization of text within the image is important for the second part of OCR, text recognition, where the text is extracted from the image.

Figure 9, OCR

3.1.7 Searching the database for License plate details

The license plate numbers of the vehicles that are allowed to enter campus premises are stored in a .csv file. The resultant string obtained from OCR is searched for in the database, if the string is present a prompt is given to allow the vehicle inside.

3.2 Experimental Background

For the implementation of this project, we have used MATLAB software which includes the “Image Processing and Computer vision” package for the required operations.

3.2.1 Input image

```
clc, clear, close all;
warning off
original = imread("pictures\2.jpg");
figure(), imshow(original), title('original')
```

3.2.2 Pre-processing for license plate detection

Here we pre-process the image to reduce noise and enhance the image features.
First, we reduce haze to enhance the illumination of the image, then convert it to grayscale and then apply a top-hat filter to enhance the white regions of the image and then finally we binarize the image. The radius of the mask for the top-hat filter is chosen to be 15 by trail and error with various images.

```
%image enhancement for low light conditions
I = original;
I = imcomplement(I);
I = imreducehaze(I);
enhanced = imcomplement(I);
figure(), imshow(enhanced), title('enhanced image')


%Converting the image to grayscale
g = rgb2gray(enhanced);


%Top hat filtering the image to seperate the number plate
se = strel('disk',15);
filtered = imtophat(g, se);
contrasted = imadjust(filtered);
figure(), imshow(contrasted), title('contrasted image')

%Binarizing the image
bin = im2bw(contrasted,0.6);
figure(), imshow(bin), title('binary image')
```

3.2.3 License plate detection

Here, we form bounding boxes for all the 8-connected pixels using “regionprops” function. And then, extract the box with the maximum number of white pixels, which provides us with the localized license plate image.

```
Iprops=regionprops(bin,'BoundingBox','Area');
area = Iprops.Area;
count = numel(Iprops);
maxa= area;
boundingBox = Iprops.BoundingBox;


figure(), imshow(bin), title('All detected bounding boxes');
[L N]=bwlabel(bin); %Label connected components
boxes=regionprops(L,'BoundingBox');
hold on

%Plot Bounding Boxes
for n=1:size(boxes,1)
    rectangle('Position',boxes(n).BoundingBox,'EdgeColor','g','LineWidth',2)
end
hold off


for i=1:count
  if maxa<Iprops(i).Area
     maxa=Iprops(i).Area;
     boundingBox=Iprops(i).BoundingBox;
  end
end
numPlate = imcrop(enhanced, boundingBox);%crop the number plate area
% numPlate = rgb2gray(numPlate);
numP = rgb2gray(numPlate);
numP = imbinarize(numP);


figure()
imshow(original);
rectangle('Position',boundingBox,'EdgeColor','g','LineWidth',2)
title('license plate location')


figure()
imshow(numPlate);
```

```
title('license plate')
```

3.2.4 Pre-processing for license plate recognition

Here, we pre-process the localized image to make it easier for OCR to recognize the text on the license plate.
The radius of the mask for the top-hat filter is chosen to be 20 and for the erosion it is chosen to be 5 through trail and error with various images.

```
%Image pre-processing to imrove results
th = imtophat(numPlate,strel('disk',20));
eroded = imerode(th, strel('line',5,0));
Iclean = imreconstruct(eroded, th);
Iclean = rgb2gray(Iclean);
bin2 = imbinarize(Iclean);
figure(), imshow(numP), title('pre processed image');
```

3.2.5 Deskewing and OCR

Here, we deskew the image if it is skewed because OCR doesn't work on skewed images. Then we localize the de-skewed image again ad apply OCR on it to get the result.
We have only chosen the lines that are longer than 40p, this will ignore all the unnecessary lines.

```
if length(number)<1
   sam=numPlate;
   gray = rgb2gray(numPlate);
   m=imadjust(gray);
   [r, c]=size(gray);
   BW = edge(m,'canny');
   [H,T,R] = hough(BW);

   P  = houghpeaks(H,1,'threshold',ceil(0.9*max(H(:))));
   lines = houghlines(BW,T,R,P,'FillGap',0.8*c,'MinLength',40);

   figure()
   imshow(H,[],'XData',T,'YData',R,'InitialMagnification','fit'), title('Hough peaks in feature space');
   xlabel('\theta'), ylabel('\rho');
   axis on, axis normal, hold on;
   x = T(P(:,2)); y = R(P(:,1));
   plot(x,y,'s','color','white');


   figure(), imshow(gray), title('hough lines'), hold on
   for k = 1:length(lines)
      xy = [lines(k).point1; lines(k).point2];
```

```
    plot(xy(:,1),xy(:,2),'LineWidth',5,'Color','green');
  end
  figure();
  if(lines.theta<0)
    g=imrotate_white(m,(90-abs(lines.theta)));
  else
    g=(imrotate_white(m,lines.theta-90));
  end
  subplot(1,2,1),imshow(sam);
  title('skewed')
  subplot(1,2,2);imshow(g);
  title('deskewed')


  %Localizing again after deskewing
  h = imbinarize(g);
  Iprops=regionprops(h,'BoundingBox','Area');
  area = Iprops.Area;
  count = numel(Iprops);
  maxa= area;
  boundingBox = Iprops.BoundingBox;


  for i=1:count
    if maxa<Iprops(i).Area
      maxa=Iprops(i).Area;
      boundingBox=Iprops(i).BoundingBox;
    end
  end
  j = imcrop(g, boundingBox);%crop the number plate area
  figure(),imshow(j),
  title('Re-localised license plate')

  %OCR
  results = ocr(j);
  number = strip(results.Text);
  number = number(isstrprop(number,"alphanum"));

  regularExpr = '\w';
  bboxes = locateText(results,regularExpr,'UseRegexp',true);
  chars = regexp(results.Text,regularExpr,'match');
  Ichars = insertObjectAnnotation(j,'rectangle',bboxes,chars);
  figure(), imshow(Ichars), title('recognized characters');
else
  regularExpr = '\w';
  bboxes = locateText(results,regularExpr,'UseRegexp',true);
```

```
    chars = regexp(results.Text,regularExpr,'match');
    Ichars = insertObjectAnnotation(numPlate,'rectangle',bboxes,chars);
    figure()
    imshow(Ichars);
    title('recognized characters')
end
number
```

```
function rotated_image = imrotate_white(image, rot_angle_degree)
    RA = imref2d(size(image));
    tform = affine2d([cosd(rot_angle_degree)    -sind(rot_angle_degree)     0; ...
                      sind(rot_angle_degree)     cosd(rot_angle_degree)     0; ...
                      0                          0                          1]);
      Rout = images.spatialref.internal.applyGeometricTransformToSpatialRef(RA,tform);
      Rout.ImageSize = RA.ImageSize;
      xTrans = mean(Rout.XWorldLimits) - mean(RA.XWorldLimits);
      yTrans = mean(Rout.YWorldLimits) - mean(RA.YWorldLimits);
      Rout.XWorldLimits = RA.XWorldLimits+xTrans;
      Rout.YWorldLimits = RA.YWorldLimits+yTrans;
      rotated_image = imwarp(image, tform, 'OutputView', Rout, 'interp', 'cubic', 'fillvalues', 255);
end
```

3.2.6 Authentication

Here, the program will match the recognized text with the database and grant entry for the vehicle if it matches any of the license plate numbers in the database. The program will match the pattern of each number in the database with the recognized text, so, even if random lines/shapes get recognized as text, the program gives correct output

```
t = readtable('data.csv');%read database


check = 0;
for i=1:length(t.Numberplates)
    if(strfind(number,t.Numberplates(i))~=0)
        check=1;
    end
end


if check == 1
    disp("Vehicle is allowed to enter")
else
    disp("Vehicle is not allowed to enter")
end
```

Chapter 4

Results

4.1 Results

We have obtained promising results in normal, mediocre, and even low-light conditions. The results are shown below.

4.1.1 Car in normal light conditions

Figure10, input image with normal light

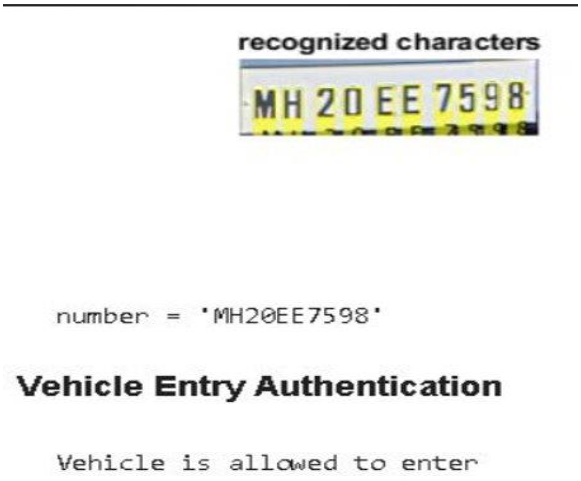

Figure 11, output for normal light image

The Fig shows the number plate of the car being analyzed by the program in normal light conditions and compares it with the data of the vehicles whether to allow the vehicle or not. Here the number plate of the car matches the data so the car is allowed to enter.

4.1.2 Vehicle in mediocre light condition

Figure 12, input image with mediocre light

Figure13, output for mediocre light image

For the image taken in mediocre lighting conditions, the number plate of the car does not match with the data, so the car is not allowed to enter.

4.1.3 Vehicle in low light condition.

Figure 14, input image with low light

Figure 15, output for low light image

For the fig taken in low light conditions, the number plate of the car matches with the data so the car is allowed to enter.

Chapter 5

Conclusion and Future Scope

5.1 Conclusion

The results analysed by the program shows better results than the base paper which was taken as a reference. Since the image containing the number plate is pre-processed to a binary image through multiple steps which helps for better recognition of the number plate. Then the pre-processed image is used to detecte the number plate using a process called localization in which a box containing the number plate is separated from the rest of the image for analysis. The next step in licesence plate detection is text recognition in whic OCR is used to identify the alpha numeric characters present in number plate. The final step in licesense plate detection is cross verify the number for authentication.

5.2 Scope for Future Work.

A deep neural network model can be programmed and trained based on datasets which helps to improve the accuracy of the license plate in terms of localization and it also helps to read the unclear number plates based on text recognition. There are chances that the license plate might not be clear or the trained model does not interpret the number plate clearly in low-light or low-illumination conditions. In such conditions, the Retinex algorithm can be used to enhance the images taken during low light conditions for better interpretation.

Chapter 6

Contribution of Each Team Member

Medisetti Nitin - 190929100

Contributions: Implementation/Research

Juvvi Manas Sashank - 190929242

Contributions: Implementation/Documentation

Bhanu Prasad A J - 190929068

Contributions: Implementation/Documentation

D Sai Shreyas - 190929238

Contributions: Research/Documentation

References

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