A Modern Approach to Automatic Number Plate Detection (ANPR) Using Machine Learning & AI

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CERTIFICATE

This is to certify that the Project entitled "**A Modern Approach to Automatic Number Plate Detection (ANPR) Using Machine Learning & AI**" is a bonafide record by (Roll No. ---------) under my supervision and guidance, in partial fulfillment of the requirements for the Degree of Bachelor of technology from Udayanath Autonomous College of Science and Technology under Utkal University for the year 2022-23.

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Signature

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ABSTRACT

Automatic Number Plate Recognition Solution (ANPR) is being used from very old days but the technology behind it remains devolved. Previous systems which are used by the Government of India[1] do not provide a real time solution for the problem. Latest advancements in the field of computer vision and decline in the prices of GPU's make real time processing of such applications possible. Therefore, it is possible to develop a real time Automatic Number Plate Recognition Solution. This paper suggests a modern approach to ANPR using latest YOLO (You Only Look Once) object detection model. Also the paper uses a CNN (Convolutional Neural Network) to perform Optical Character Recognition (OCR).

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1. INTRODUCTION :

Automatic Number Plate Recognition (ANPR) is a technique designed to read vehicle number plates without human intervention using high speed image capture with supporting illumination, detection of characters within the images provided, verification of the character sequences as being those from a vehicle number plate, character recognition to convert image to text; so ending up with a set of meta-data that identifies an image containing a vehicle number plate and the associated decoded text of that plate. Most members of the public will be aware that ANPR is used by police forces to track criminal behavior on the road. However, ANPR is used in a variety of other ways to support the security and safety of the public, as well as supports the way we interact with transportation and vehicle-based infrastructure.

The software aspect of the system runs on standard home computer hardware and can be linked to other applications or databases. It first uses a series of image manipulation techniques to detect, normalize and enhance the image of the number plate, and then optical character recognition (OCR) to extract the alphanumeric of the license plate.

This documentation presents implementation of a deep learning based ANPR technique. We test the program based on our analysis on bike number plate and store number plate text and image into a directory. Any number plate can be searched from this directory as the file name is the predicted text from the implemented ANPR algorithm. Results demonstrate the accuracy of the ANPR technique on various scenarios. A detailed description of pre-processing techniques and alphabet/number extraction algorithms are presented. Multiple alternative methods have also been compared to determine the optimal solution. We then describe our program architecture and its various components and tuning parameters which can be manually changed to obtain desired results.

2.LITERATURE REVIEW

EXISTING METHOD: -

To create a society without human intervention cars can be used as a Proof of Identity(PoI) and the unique registration plate number provides the opportunity to track the movement of cars in turn tracing humans that are associated with that car. This was identified in the past that is why tracing of cars is being used from as early as the 1980s. Advancements in computer vision techniques now allow us to do that automatically without human intervention.

'Feature based number plate localization'[2] is a technique that is used for number plate localization. This approach consists of a number of algorithms developed on the basis of general features of both, characters and number plate. For pre-processing, the input gray-scale image is adaptively converted into binary image using Otsu's method. A mask having the shape of inverted 'L' and size equal to maximum possible character dimensions is rolled throughout the binary image. At every increment a position is shortlisted as possible character location if there is at least a single white pixel in the region and there is at least a single white pixel on the immediate next row and column of the region. Size of each shortlisted character calculated. If it is less than half of the maximum possible character size that location discarded. Subsequently multiple detected portions are discarded using filters such as white pixel density, height and width and one final region is decided to recognize characters. If cases where the number plate script is not in English language or the number plate is barely visible are excluded then, 82% of the plates were recognized correctly which means in ideal conditions it was able to predict correct outcome only 82% times. The performances of individual sections are 87% for number plate localization and 85% for character recognition and 95% for character segmentation.

Most of the algorithms use features of number plates to localize the area of number but none them treats number plate as an object. We are trying to use object detection algorithms which perform better on low end GPUs and provide less response time which will allow us to detect in real time.

PROPOSED METHOD: -

In other approaches images are first preprocessed and then number plate area is detected [3]. But in this case as we are using object detection algorithms to detect the number plate there is no need to use binarization and median filtering instead they will be used in character recognition step. The measure steps that are going to be followed are :

1. Number Plate Localization.
2. Image preprocessing
3. Character Segmentation
4. Character Recognition.

1. Number Plate Localization:

The very first step in the system we are trying to propose is to detect the number plates from the image we are passing. Consider the Number plate as an object and to recognize it we have to use different object detection algorithms. There are two different concepts which come into picture which are object classification and localization. Classification is nothing but classifying the type of object like a car, bike or a person and localization is locating where the particular object is in the image by drawing lets say a bounding box over it. Object detection is a combination of both classification and localization of the object in the image. The GPU centric, efficient algorithm we are proposing to use to detect the object area from the image is the YOLO algorithm(You Only Look Once)

What is YOLO algorithm?

You Only Look Once (YOLO) is a state-of-the-art, real-time object detection algorithm introduced in 2015 by Joseph Redmon et al. in their famous research paper “You Only Look Once: Unified, Real-Time Object Detection”[4].

Object detection is a computer vision task that involves identifying and locating objects in images or videos. It is an important part of many applications, such as surveillance, self-driving cars, or robotics.

How does YOLO work?

YOLO first divides the image in 13*13 of which each cell detects five bounding boxes (the bounding box is the rectangle which encloses the object). YOLO gives a confidence score which shows how confident the algorithm is that the object to detect exists in the bounding box. The score doesn't tell the type of object but tells the confidence score if it is in that bounding box or not. Now we know there are n*n grid cells and each detects 5 bounding boxes, so total bounding boxes will be n*n*5 that is 185. For example there are 13*13 grid cells and each cell detects 5 bounding boxes so total bounding boxes becomes 13*13*5 which makes 845 bounding boxes. Now the beauty of the algorithm is that these total 845 boxes were predicted all at once as the name suggests “You Only Look Once”.

The first version of YOLO was proposed in 2016 and the latest version of YOLO which is YOLOv8 has been proposed in 2023 which we have used to implement our algorithm in this paper.

YOLOv8 is the newest state-of-the-art YOLO model that can be used for object detection, image classification, and instance segmentation tasks. YOLOv8 was developed by Ultralytics, who also created the influential and industry-defining YOLOv5 model. YOLOv8 includes numerous architectural and developer experience changes and improvements over YOLOv5. YOLOv8 is built on cutting-edge advancements in deep learning and computer vision, offering unparalleled performance in terms of speed and accuracy. Its streamlined design makes it suitable for various applications and easily adaptable to different hardware platforms,from edge devices to cloud APIs.

2. Image Preprocessing

To achieve only characters from an image/video of an entire environment, image preprocessing is very crucial step. In this process we use various pre-processing techniques to produce an image which only contains desired number plate characters and numbers.

3. Character Segmentation:

Character segmentation is an operation that seeks to decompose an image of a sequence of characters into sub images of individual symbols. It is one of the decision processes in a system for optical character recognition (OCR). Its decision, that a pattern isolated from the image is that of a character (or some other identifiable unit), can be right or wrong. The image is looked for any pixels that satisfy the necessities. At whatever point such a pixel is experienced, its neighbors are checked, and if any of the neighbors likewise parallel the criteria, both the pixels are measured as have a place with the same region. We use simple contouring technique to perform this step.

4. Character Recognition :

After detecting the number plate area it needs to be cropped from the input image and feed forward to a character recognition network. Before that the cropped number plates need to be preprocessed to get a more accurate output. In this step, various computer vision techniques are used to produce a image only with number plate characters. From it, individual characters are segmented and then passed to perform OCR. We perform this step using template matching technique. We used a pretrained CNN model[5] (trained using the char74k data-set[6]) to perform template matching on individual character segments.

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets have the ability to learn these filters/characteristics.

Template matching is useful for recognition of fixed sized characters. It can be also used for detection of objects generally in face detection and medical image processing. It is further divided in two parts: feature based matching and template based matching. Feature based approach is useful when template image has strong features otherwise template based approach can be useful. In [8] statistical feature extraction method is applied for achieving 85% of character recognition rate. In [9], several features and extracted and salient is computed based on training characters. A linear normalization algorithm is used to adjust all characters with uniform size. The recognition rate of 95.7% is achieved among 1176 images.

3.TECHNOLOGIES

ABOUT PYTHON

Python is strong and fast, performs nicely with others, is person pleasant and clean to learn, and is open source. It is an all-round precious programming language utilized in Dialog flow. It is used as a base for the maximum distinguished Abased programming in mild of its versatility, straightforwardness and longstanding reputation. Python is a high-level, all-purpose programming language with a built-in interpreter.

Python is an interpreted programming language. Python is an exceptional programming language to study and you can use it in an expansion of areas in software improvement. you could use Python for internet development, records analysis, device studying, artificial intelligence, and more. Python's concise and easy clarity allows AI specialists to write down easy structures which might be dependable. This lets in the developers to resolve complicated gadget getting to know troubles in preference to coping with technical issues of the language. often, programmers fall in love.

We have used python to program the code required for the completion of tasks. Python is an easy to learn programming language which has many numerous amounts of libraries and packages which are already present which are available to use freely. Like how many different libraries are present and for diverse amounts of applications like data analytics, automation etc., and debugging applications is clean: A segmentation fault will not be caused by a computer virus or malicious code.

PYTHON IS WIDELY USED IN MACHINE LEARNING

Python gives concise and readable code. It offers admission to numerous flexible libraries and frameworks. It is greatly intuitive than different programming languages. Python emphasizes productiveness and readability. Python apps are available for infographics, artificial intelligence, natural processing of language, sophisticated data examination, also with many other tasks. The maximum famous libraries and equipment for Machine learning are:

YOLO:

YOLO (You Only Look Once), a popular object detection and image segmentation model, was developed by Joseph Redmon and Ali Farhadi at the University of Washington. Launched in 2015, YOLO quickly gained popularity for its high speed and accuracy.

- YOLOv2, released in 2016, improved the original model by incorporating batch normalization, anchor boxes, and dimension clusters.
- YOLOv3, launched in 2018, further enhanced the model's performance using a more efficient backbone network, multiple anchors and spatial pyramid pooling.
- YOLOv4 was released in 2020, introducing innovations like Mosaic data augmentation, a new anchor-free detection head, and a new loss function.
- YOLOv5 further improved the model's performance and added new features such as hyperparameter optimization, integrated experiment tracking and automatic export to popular export formats.
- YOLOv6 was open-sourced by Meituan in 2022 and is in use in many of the company's autonomous delivery robots.
- YOLOv7 added additional tasks such as pose estimation on the COCO keypoints dataset.

Since its launch YOLO has been employed in various applications, including autonomous vehicles, security and surveillance, and medical imaging, and has won several competitions like the COCO Object Detection Challenge and the DOTA Object Detection Challenge.

NUMPY

It is a Python package. It stands for Numerical Python. It's far an array which contains multidimensional array gadgets and series of routines for processing those arrays. the usage of this library, on arrays we can carry out logical and mathematical operations.

IMUTILS

Imutils are a series of convenience functions to make basic image processing functions such as translation, rotation, resizing, skeletonization, and displaying Matplotlib images easier with OpenCV and both Python 2.7 and Python 3.

OPENCV

Open-Source Computer Vision Library is a common platform and set of programming functions for real-time applications. The open CV library contains several algorithms for more than 500 optimized algorithms. Used mostly around the world, with forty thousand people in the user group. The first languages used in C-C ++ are mainly written in C, making them portable to certain platforms such as the digital signal processor. Now the language that is called Python is being used recently, has been developed to encourage adoption by a wider audience. These languages recent versions have interfaces for C ++. Open CV is a multi-platform library, containing C ++, Python, and Java interfaces. Open CV is designed to achieve computational efficiency with a strong focus on real-time applications.

4. IMPLEMENTATION

Vehicle Image Capture: -

In the first step, the input image is captured from a source in landscape mode. To perform license plate detection, we first resize it to a standardized resolution of 1280*720 pixels. Then we pass it to our YOLOv8 model to detect the license plate.

Figure 1: The Resized Input Image

If the model detects the number plate object within the image, it returns a results object that contains information about the bounding box coordinates of detected license plate with other details. We use this information to plot the bounding box in the input image as follows.

Figure 2: YOLOv8 License Plate Detection

Pre-processing: -

The bounding box coordinates are used to crop the the license plate from the input image. This cropped image is then resized to a normalized size of 500*250 pixels for pre-processing purpose. This image is shown below.

Figure 3: Cropped License Plate in 500*250 px resolution

Since the image is influenced by many elements like: Optical system distortion, system commotion, lack of presentation or over the top relative motion of camera or vehicle, so the detected number plate image is pre-processed before character extraction from that vehicle number plate.

The various preprocessing steps performed are:

1. Skew Correction(De Skewing)
2. Shadow Removal
3. Grayscale Conversion
4. Noise removal
5. Image binarization
6. Erotion & Dilation
7. Blob Removal

1. De Skewing(Rotation)

A bird's eye view of the input image is crucial for charcter extraction. Thus first the image's skew is removed and it's straightened to get a top to down or bird's eye view as follows.

Figure 4: Deskewed Image

2. Shadow Removal

Shadows in image can lead to unexpected results during image binarization process. Ignoring the existence of shadows in images can degrade the output quality also. Thus in step we remove the shadows from the deskewed image using a series of techniques. It results in following image.

Figure 5: Shadow Removal

3. Grayscale Conversion

Once the image is straightened and the shadows are removed, the image is converted to grayscale format. This is done due to many techniques in OpenCV library require a grayscale image as input to work. The grayscaled image is shown below.

Figure 6: Grayscale Conversion

4. Noise Removal

In this step we remove various noises from the image to smoothen the image processing in binarization step. The process gives following output.

Figure 7: Denoised Image

5. Image Binarization

Image binarization is the process of taking a grayscale image and converting it to black-and-white, essentially reducing the information contained within the image from 256 shades of gray to 2: black and white, *a binary image*. This is sometimes known as *image thresholding*. In our project, we perform Otsu's thresolding[7] to perform image binarization. The following image shows the binarized output:

6. Erotion & Dilation

The binarized image then goes a series of erotion and dilation to refine pixel edges and improve image quality. This process gives below output.

Figure 8: Output of Erotion & Dilation Process

7. Blob Removal

This is the last and most crucial part of image preprocessing pipeline. Although the image from Step-6 contains considerably less noise(unimportant informations), it also consists many white pixels except number plate charcters that are unnecessary for OCR process. These pixels are also called *blobs.* In this process we use OpenCV library's Connected Component Analysis function to remove any undesired white blob. We also remove the 'IND' characters from license plate since these characters are redundant as we are performing this algorithm for Indian License Plates.

This step is optimized for two row Indian HSRP license plate characters. The output is shown below.

Figure 9: Final Output Of Image Preprocessing

Character Segmentation and Extraction: -

Segmentation is a section of image processing for the separation or segregation of information from the required target region of the image. Once contours are detected they can easily be separated from the rest of the image.

In our project, the preprocessed image only contains the desired number plate characters for OCR. So the characters are easily segmented from each other using simple contour detection technique. In this process, contours are first detected for number plate characters are number. Then using these contour information, a bounding rectangle is calculated and drawn around each character and number. The following picture demonstrates this process.

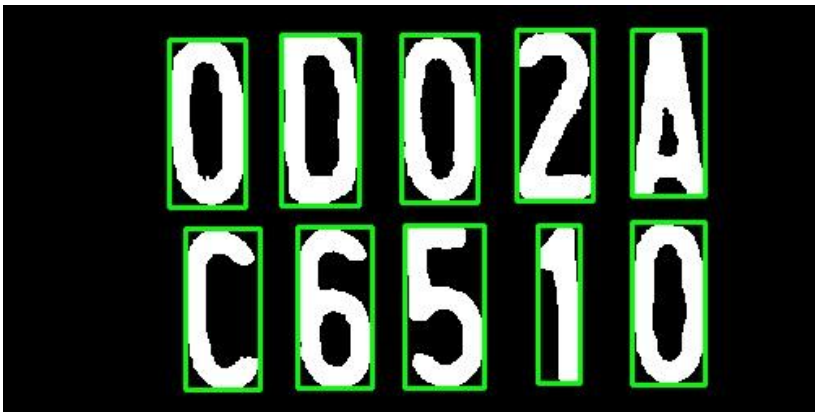


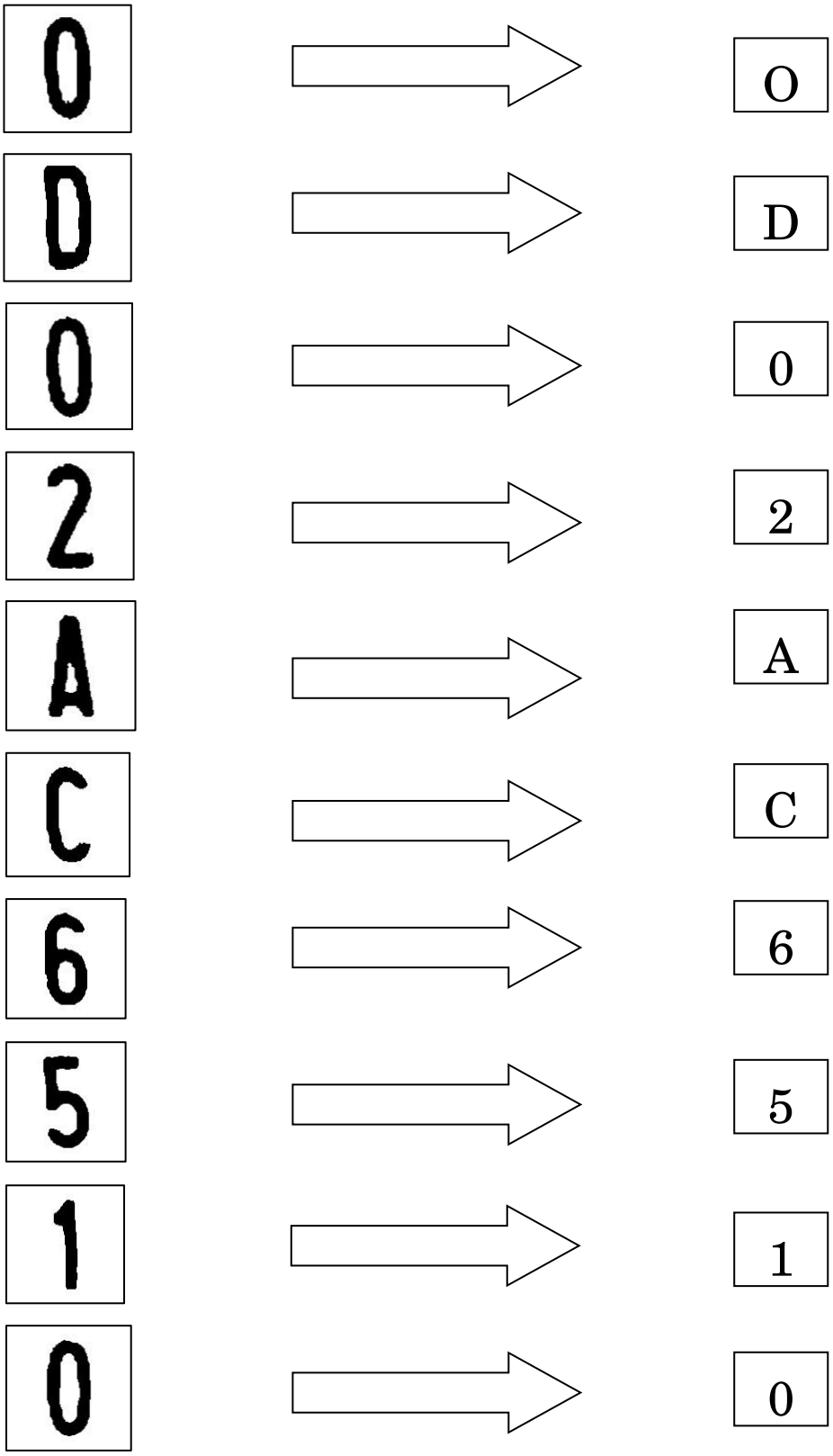
Figure 10: Character Segmentation

After defining bounding box for each character in above process, we crop or extract each individual characters from the image. These individual characters are then passed to the AI OCR model for detecting the text.

Character Recognition: -

The last step of the ANPR system is character recognition. In this step, we resize the cropped characters to 128*128 pixels resolution. Then we pass each characters to the CNN model to perform OCR.

Following figures demonstrate this process.



The result of the OCR is stored in a character array which are plotted in the full image. This is shown below.

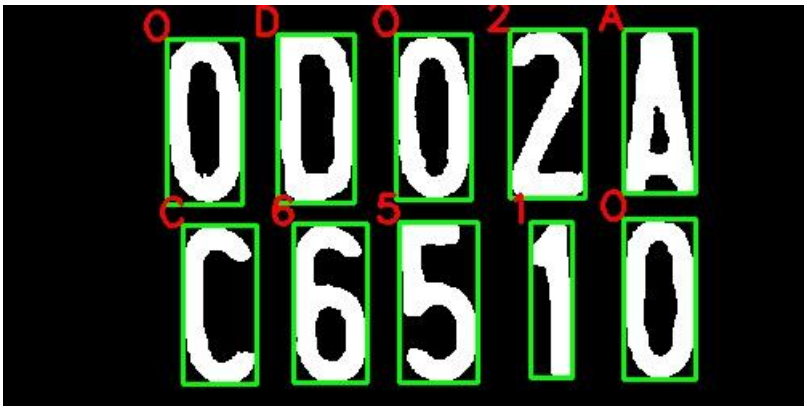
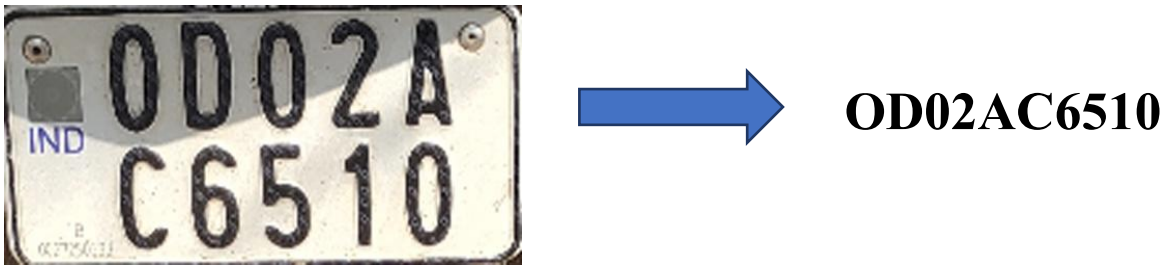


Figure 11: Character Recognition

6. FINAL OUTPUT

So, after running the whole code we obtained the value of number plate of a vehicle from an input image taken.

The below figure is how the final output looks like.



7. CONCLUSION

From our proposed system we can conclude that the technology that we will be using can be successfully used to detect the number plate region from the image which consists of vehicle number & then character segmentation and recognition.

We will be applying this technology on many images and can be used to successfully recognize the numbers from vehicle number plate. This project is designed keeping in mind the automation of the number plate detection system for security reasons. Our data can be used for many purposes such as stolen vehicle, capturing the over speeding etc. and many more that could replace the current system of manual system.

Further work of this is to take the input through webcam or taking the video of moving vehicles as input so that it will be beneficial to an individual more and we try to work on bringing more efficiency using novel techniques. We would do the performance analysis in terms of number of plates successfully recognized. So far, the algorithms look good and suitable but if the OCR algorithm won't work than we will try to give some new algorithm or would do the comparative study of different OCR present in the market and would try to choose the best among them and implement the system.

8. FUTURE OUTCOME

The future scope is that the automatic vehicle recognition system plays a major role in detecting threats to defense Also it can improve the security related to the women's as they can easily detect the number plate before using cab or other services. The system robustness can be increase if bright and sharp camera is used.

Government should take some interest in developing this system as this system is money-saving and ecofriendly, if applied effectively in various areas.

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