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Smart System for Indian License Plate Detection and Recognition Using Deep Learning Techniques

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Abstract- Vehicle number plate (license plate) detection and recognition system (VLPDR) using image processing methods is a potential research area in smart cities and the Internet of Things. Recognizing a vehicle's license plate is necessary because the number of vehicles increasing and it goes beyond human's ability to complete this task. The vehicle license recognition system commonly contains 2 sub-systems: license plate detection, which aims to locate the vehicle and its license plate; and license plate recognition, which aims to recognize the characters on the plate. This project focuses on both sub-systems by researching Indian vehicles. The type of plate is a single-line containing 1 line of character sets, which represents registered state, registered RTO code, and registered numbers respectively from left to right. This project revolves around an approach to deep learning with some image processing concepts. Here, for the detection of the License plate from an input image a pre-trained object detection algorithm, YOLOv3 is used which is very fast and as accurate as Single Shot Multibox Detector (SSD), while the recognition phase deals with segmenting and training the license plates by using deep learning (OpenCV and Keras). The final output of the license plate is displayed. The accuracy of this project for object detection is very high for a good resolution image input and for recognition the accuracy is high.

Keywords: - License plate detection, RTO, YOLOv3, SSD, Open CV, Keras.

I. INTRODUCTION

In today's world vehicles is one of the most important things in day-to-day usage for humans. In every residential building and also in public government sectors there are lots of vehicle movements i.e., entering and exiting the buildings.

Due to this, there happens a large number of crimes, traffic violations, car bombs, larceny, etc. So, it is important to have a security system.

For this, a manual method where the security guard recording the license plate manually in his entry records can be done, but it's expensive, tedious, and has a high error rate. So, a Vehicle license plate

This project aims to apply a deep learning approach to detect and recognize vehicle license plates in India. Although many robust approaches have been employed by prior research, the deep learning approach has to gain dramatic attention in recent days in the field of pattern recognition. Deep learning is a branch of machine learning which is specifically based on artificial neural networks, as the neural network is going to mimic the human brain so deep learning is also a kind of mimic human brain.

For detection, there are many object detection algorithms but Single Shot 2 Multibox Detector (SSD) has been always known for its accuracy but it lacks computing speed, YOLO is a new popular algorithm and it is as accurate as SSD and also has high

computing speed. In recognizing the characters, many algorithms have been found in that literature. For example, Hidden Markov model; hybrid discriminative restricted Boltzmann machine, Support Vector Machine (SVM), template matching is a technique suitable for recognizing characters that have single-font, not rotated, and fixed-size properties.

Additionally, the convolution neural network has also received high attention due to its great capability in classifying the license plates.

This project applies object detection algorithms for detecting the license plate in an image, image processing on the detected area where the license plate is found, segmentation of characters and training the convolution neural network model and then recognizing the license plate and displaying output which all are under the hood of deep learning.

As the Intelligent Transportation System (ITS) uses surveillance, detecting and extracting the LP under various situations has been challenging tasks like low contrast, low brightness, uneven illumination, etc. Besides this, every vehicle is also allotted a unique license number which is used to retrieve the information about the owner of the vehicle. So, to get accuracy is a difficult task. This project aims to achieve high accuracy and provide great results for the challenges mentioned.

II. REVIEW OF LITERATURE

Existing research work by **[1] Wichai Puarungroj et al** proposed a method to detect and recognize number plates. The research focuses on recognizing Thai motorcycle license plates. Firstly, the three lines of license plates were segmented by using SSD and trained by using Inception- v3 and Mobile Nets, and secondly, the characters on license plates are segmented and trained by the same set of approaches. The models from training steps were employed to test the whole set of license plate images. The challenges in this research were that many license plates were partly covered by improper frames. The frame hid some parts of the plate even when viewed by human's eyes. From this case, the research found that the characters, in this case, were stilled detected and recognized.

According to the work of **[2], Shraddha S. Ghadge et al,** the system automatically recognizes an un-authenticated vehicle by using image processing and deep learning algorithms. Record of an authenticate vehicle along with the owner information in residential areas is stored on the LAMP server. Whenever the vehicle arrives at the parking system, an ultrasonic sensor detects the distance and presence of the vehicle. Then the camera will initialize and capture video frames.

Using SSD-Mobile Net deep learning model vehicle 5 number plate is detected. The recognized number is matched with the recorded database. After the vehicle status is displayed on the Website created using the Django framework. If the number matches, then the gate opens which is controlled throughout the Servo motor. If the number does not match, means the vehicle is un-authenticated and the gate remains closed and it will send an email through SMTP to the parking management authority.

The study by **[3] Cheng-Hung Lin et al** proposes a new two-stage methodology based on deep learning technology which first detects all the license plates in a picture and extracts the license plate images, and then performs character recognition using Convolutional Neural Networks. The first stage of the license plate detection model is mainly used to capture the license plate position on the screen as the region of interest (ROI). The ROI image is then sent to a character recognition model for license plate character recognition. It uses the object detection architecture YOLOv2 to directly perform character recognition to reduce the complexity and to add over exposed, under exposed, blurred, and skewed license plate images as training samples to improve the character recognition rate.

Based on the study of **[4] Naren Babu R et al** created their recognition model by training on our manually collected car number plate dataset using YOLO V3. The proposed approach has three subdivisions (i.e., Number Plate Detection, Number Plate Recognition, Sorting the output). In this work, A single YOLO model is used for both number plate detection and recognition. They trained a 37-c1ass CNN to recognize all the characters in the number plate and detect the number plate itself (i.e., Number Plate, A-Z (except 0), 0- 9). Since 0 and O are recognized as the same, they neglect o for training. An input image is fed into the YOLO model, then if

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the number plate is detected, the corresponding number plate region of interest (RO\) is extracted and this image is again fed into the YOLO model to get recognized. Finally, the recognized output is sorted from left to right so that it's in the correct order as in the number plate.

The research work by **[5] Joseph Tarigan et al** Genetic algorithm was used to define the optimal learning rate, momentum rate, and the number of neurons in the hidden layer of 6 a back propagation neural network. Then the back propagation neural network is applied in the plate number recognition system.

First, every input image will be scaled. And convert the image into the grey scale image and summarize the result with the unwanted area such as reflection from the number plate is eliminated and the threshold function is optimized. Top hat transformation was utilized.

The rectangular structuring element with size 41 by 27 pixels was used. Next, the Otsu threshold was applied to the image to transform the grey scale image into the binary image to separate the character candidates. Binary closing was applied to the image. Then, erosion was applied to the image to erode the character area to obtain the optimal result.

In the work done by **[6] Mallikarjun Anandhalli et al,** A system with Raspberry Pi and a USB camera is being used for real-time vehicle detection, tracking, and counting. The density of the vehicles running on the particular road will be determined in real-time. The results of the proposed method in terms of its accuracy and time taken are better compared to the rearview vehicle detection and tracking method and morphological operation method. Because of the static IP address assigned to the Raspberry system it enables to communicate it with other remote computers.

The performance of the proposed system is found superior by 6% to 8% when compared to rearview vehicle detection and tracking method and morphological operation method. It has been experienced that cost of the proposed system is much less than the existing systems. Detection of the vehicle and tracks made by the system is reliable. The proposed method considered only the color features of the vehicle and made it replace the existing systems. The numbers of vehicles present in the video are calculated in real-time.

According to the work done by **[7] Selim S. Sarikana et al** a vehicle flow detection approach to distinguish traffic anomalies is presented. Optical flow estimation is performed to detect motion. Moreover, the machine learning technique k-nearest neighbor is adapted for unsupervised learning. Different illumination levels during daytime and nighttime are observed. A varying range of vehicles including motorcycles, cars, trucks, and buses will be detected. The results from public motorway tests showed that the proposed detection method and can detect vehicles traveling opposite the traffic flow. This information can be used to 7 notify traffic operators in real-time.

However, the proposed method requires dedicated cameras for each lane. As an extension, this method can be extended to work with a single camera covering the entire road surface. From a machine learning point of view, feature selection and feature extraction remain the most important issues. Selected features affect overall accuracy significantly.

The research was done by **[8] Ravi Kiran Varma Pa et al** deals with Number Plate Detection and Number Plate Recognition, concerning Indian vehicle number plates or license plates. The major contributions of this work include consideration of challenging situations like illumination, blurred, skewed, noisy images, non-standard and partially worn-out number plates. In this work firstly, several image processing techniques, morphological transformation, Gaussian smoothing, Gaussian thresholding are used in the pre-processing stage.

Next, for number plate segmentation, contours are applied by the border, and follow contours are filtered based on character dimensions and spatial localization. Finally, after the region of interest in filtering and de-skewing, the K-nearest neighbor algorithm is used for character recognition. For future work, they would like to incorporate a Convolutional Neural Network that combines both detection and recognition into a single framework. CNN's are proven to work well with the images, provided that a huge amount of data is available. This is just to avoid over fitting data and perform better in generalizing unseen data.

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The existing research was done by **[9] K.B. Sathyaa et al** CN have provided the better performance of accuracy for recognition task when combined with data augmentation. The performance gain can be achieved by increasing the number of epochs. Hence deep learning-based CNN is the process of increasing the number of hidden layers for efficiently training the features along with the data augmentation. It is commendable that our system, with all possible variations in the data, can recognize the license plate string correctly with an accuracy of 95% and it can also be enhanced with an Internet of Vehicles for intelligent traffic control.

Deep architectures for Location and Recognition of VLPR can be deployed & improved for computational complexity on the account of Partial Occlusion. The visual quality effects can also render using Sparse coding, Dictionary learning & RNN also, the 8 Algorithms has to be implemented for real-time occluded annotated free application such as Rain streak removal, Shadow removal, Snow/Fog, etc.

Based on the work done by **[10] Ayodeji Olalekan Salau** is an efficient and robust algorithm for vehicle plate number localization has been presented. The proposed algorithm is not country-specific and can be used to detect LPs of different sizes, orientations, complex backgrounds, varying illumination, and weather conditions. Then, the feature is extracted from the image and the image is normalized in an 8 × 16 pixel. Then, the feature is extracted from the image and the image is normalized in an 8 × 16 pixel. The experimental result shows that this algorithm has high accuracy, reaching 99.8% and a corresponding fast processing time of 0.21 s. In future works, this approach will be further extended to localize the license plate of motorcycles.

III.EXISTING SYSTEM

In the existing system, the research is primarily focused on Thai motorcycle license plate detection which is of triple line plate type. These three lines of license plates are segmented by using the SSD and trained by using the Inception-v3 and Mobile Nets and secondly, the characters on the license plates were segmented and trained by the same set of approaches.

1. Drawbacks:

It has the drawback of not recognizing the characters except Thai. Moreover, the system is majorly focused on the detection and recognition of the Thai motorcycle license plate. The resulting accuracy is good but the system is quite slow.

IV.PROPOSED SYSTEM

In this paper, we detect and recognize the license number in the Number plate of Indian vehicles. For detecting the number from the captured image of the Indian number plate of vehicle we used object detection algorithm YOLO V3 for detecting license number in the vehicle. The image will go for segmentation and in that candidate, the region will be done for feature extraction and undergo some numerical computations using Tensor Flow open source.

The enhanced segmented image will now do with deep learning Trained CNN to predict the exact number and alphabet in the image. And the predicted image is the feature extraction of the recognition phase and result.

1. Advantages of Proposed System:

The skilled classifier is proven to be correct and has low false positives and negatives. The contributions state-of-the-art this paper is as follows:

- We achieved high accuracy and provide great results in extracting the license plate using the deep learning technique CNN.
- We used the YOLO v3 algorithm for detection to detect the image in the fastest manner than another detection algorithm.

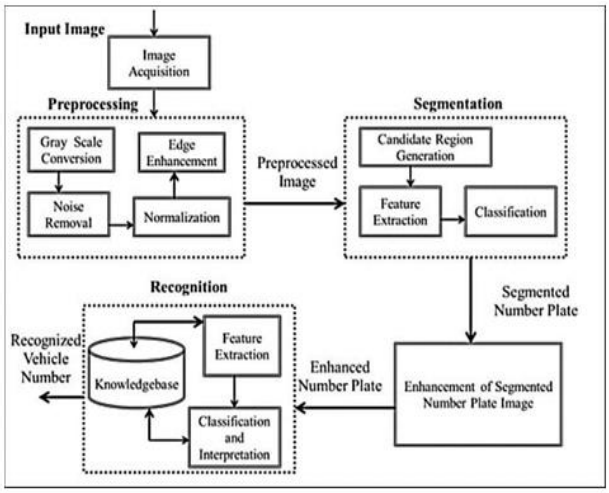

Fig 1. System Architecture of proposed.

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2. Requirement Specification:

These are the hardware and software requirements to develop the system.

3. Hardware Requirements:

- Computer with a Quad-core processor.
- 8GB of RAM.
- 15GB of disk storage space.
- Nvidia GTX 980 or equivalent graphics card.

4. Software Requirements:

4. 1 Open CV: OpenCV is a programming functions library that mainly aimed at real-time computer vision.

4. 2 Python 3: Python is a programming language that is majorly used in Artificial Intelligence concepts.

4. 3 Jupyter Notebook: It is an open-source web application used to create and share documents with live code and narrative texts of software. 10

4. 4 Tensor Flow: It is open-source for numerical computations and large-scale machine learning.

4. 5 Keras: An open-source library that provides a python interface for Artificial Neural Networks and runs on top of Tensor Flow.

4. 6 Scikit-Learn: It is free software for machine learning library for Python programming.

5. System Design:

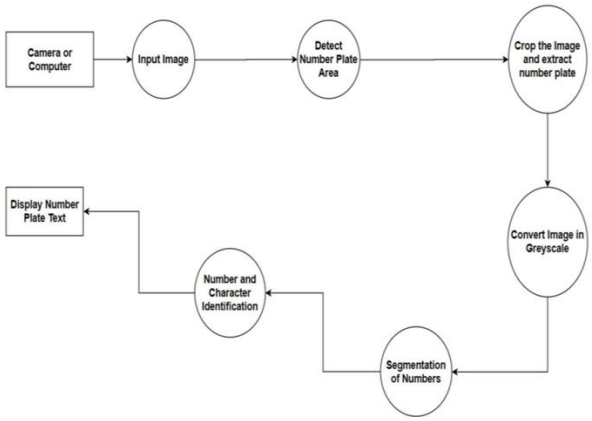

Fig 2. Data Flow Diagram.

6. Object Detection:

In the first phase, we perform Object Detection using Yolo V3. Object Detection is a computer vision technique in which the software system can detect, locate, and trace the object from a given image or video. The special attribute of object detection is that it identifies the class of objects like (person, chair, etc.) and their location-specific coordinates in the given image. The location is pointed out by drawing a bounding box. The bounding box may or may not accurately locate the position of the object. The ability to locate the object inside the image defines the performance of the algorithm used for detection. Face detection is also one of the examples of object detection. These object detection algorithms may be pre-trained or can be trained from scratch. In most use cases, we use pre-trained weights from pre-trained models and then fine-tune them as per our requirements.

7. Image Pre-Processing:

Image Pre-Processing is the analysis and manipulation of an image, especially to improve its quality. It is the field of knowledge that falls in Computer Vision. The premises of the machine learning were first laid down by the computer vision theory, applying a whole set of techniques to process and analyze imagery data to extract valuable information that computers and machines may use for a wide range of applications, such as Stitching, Morphing, 3D Modeling, Face detection, Visual Authentication. Image processing is a prior step in computer vision, where the goal is to convert an image into a form of suitable for further analysis. Examples of operations such as exposure correction, color balancing, image noise reduction, or increasing image sharpness are highly important and very care demanding to achieve the acceptable results in most computer vision applications like computational photography and even face recognition.

8. Image Segmentation:

Segmentation is one of the most important processes for the identification of license plates because any other step is based on segmentation. In this step, some more image processing to extract the individual characters from the license plate. After cropping the license plate, next step is character segmentation. Character segmentation is to separate the alphanumeric characters on the license plate individually. In this process, we first extract the candidates of the features. The common feature of them is dark. To obtain them, we will extract the darker regions by connecting all the dark pixels. To extract the dark circular regions, we used the degree of separability and at the dark pixels; two regions are defined by making three concentric circles. We compute ratio in between-class variance of the brightness and the total variance of the two regions. In each darker region, the pixel having the maximal separability is extracted as a feature candidate point.

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And the Feature extraction is a part of dimensionality reduction process, in which, an initial set of the raw data is divided and reduced to more manageable groups when you want to process it will be easier. The technique of extracting the features is very useful when you have a largest data set and need to reduce the number of resources without losing any important or relevant information. Feature extraction will help to reduce the amount of redundant data from the data set.

9. Image Recognition:

Character recognition helps in identifying and converting text images into editable text. As most of the number plate recognition algorithms use a single method for character recognition. For Character recognition, CNN is used.

The Convolutional Neural Network consists of an input layer, some hidden layers, and an output layer. The hidden layers usually contain convolutional layers, ReLU layers, pooling layers, and that they are fully connected layers. After that, the convolutional layers will be applying a convolution operation to the input. This passes the information to the next layer. Pooling combines the outputs of clusters of neurons into one neuron within the next layer. Fully connected layers are connected to each neuron in one layer to each neuron within the next layer.

CNN works by extracting features from images. This eliminates the need for manual feature extraction. The data is all clean now create a Neural Network which will be intelligent enough to acknowledge the characters after training.

10. Convolutional Neural Network:

- To create a model, we have used a Convolutional Neural Network with three layers.

```
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_5 (Conv2D)            (None, 28, 28, 32)        55328
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 14, 14, 32)        0
_________________________________________________________________
dropout_4 (Dropout)          (None, 14, 14, 32)        0
_________________________________________________________________
flatten_4 (Flatten)          (None, 6272)              0
_________________________________________________________________
dense_8 (Dense)              (None, 128)               802944
_________________________________________________________________
dense_9 (Dense)              (None, 36)                4644
=================================================================
Total params: 862,916
Trainable params: 862,916
Non-trainable params: 0
_________________________________________________________________
```

Fig 3. Sequential Model.

- The first layer will be a convolutional layer with 32 output filters, a convolution, the window of size (5,5), and 'ReLU' as activation function.

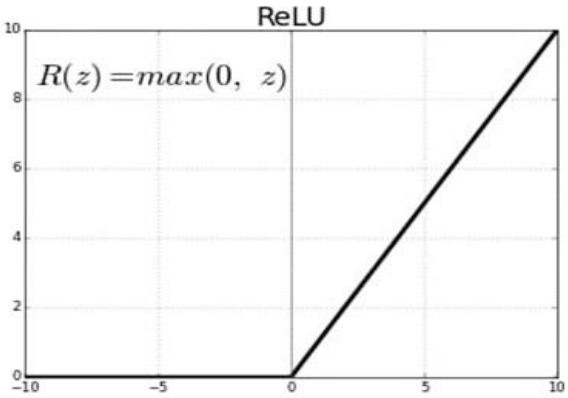

Fig 4. Activation Function.

- The next layer is the Max-pooling layer with a window size of (2, 2). Max pooling is a sample-based discretization process. The main aim is to reduce or to down-sample the input (image, hidden-layer output matrix, etc.), which will be reducing its dimensionality and allowing assumptions to be made about features present in the sub-regions binned.

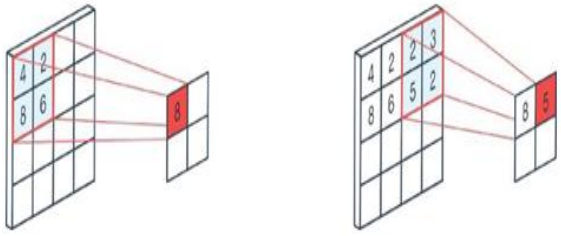

Fig 5. Max Pooling Layer.

- Dropout rate to take care of over fitting. Dropout is used to prevent Neural networks from over fitting where a regularization hyper parameter is initialized. Dropout is a method where the randomly chosen artificial neurons are not considered during training. They are "dropped-out" randomly. We have chosen a dropout rate of 0.4 meaning 60% of a node will be retained.

- Next is flattening layer to flatten the node data. The flattening layer takes data from the previous layer and represents it in a single dimension.
- At last adding 2 dense layers, one with the dimensionality of the output space as 128, activation function='relu' and other one is the final layer with 36 outputs for categorizing the 26

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English alphabets which are from A to Z and 10 numeric digits from 0 to 9 and the activation function=' softmax'.

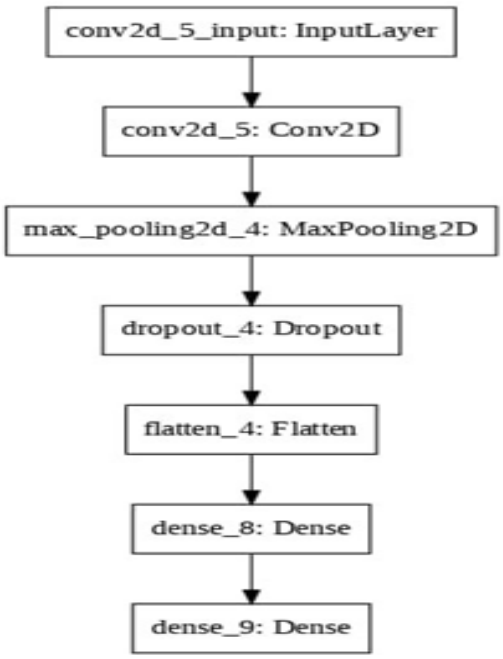

Fig 6. Convolution Layers.

11. Training CNN Model:

For training the CNN model, the data we will be using consists of images of English alphabets from A to Z and Numeric digits from 0 to 9 of size 28x28, the data is also balanced so data tuning is not required.

The Image Data Generator class available in Keras to generate some more data using image augmentation techniques like width shift, height shift.

- **Width shift:** Accepts the float value denoting by what fraction the image will be shifted left and right.

- **Height shift:** Accepts the float value denoting by what fraction the image will be shifted top and bottom.

For training 'categorical cross entropy' as loss function, 'Adam' as optimization function, and 'Accuracy' as our error matrix. After training for 66 epochs, the model achieved an accuracy of 98%.

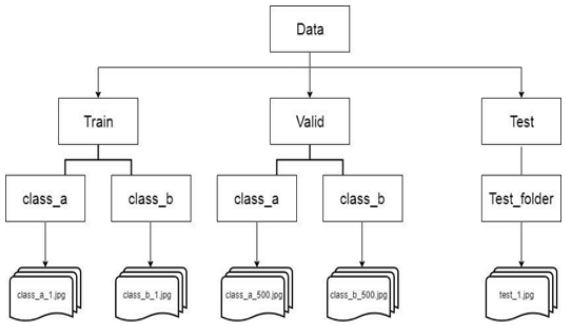

Fig 7. Image Classification using Keras.

V. RESULTS

Fig 8. Input Image.

Fig 9. License Plate Detected Image.

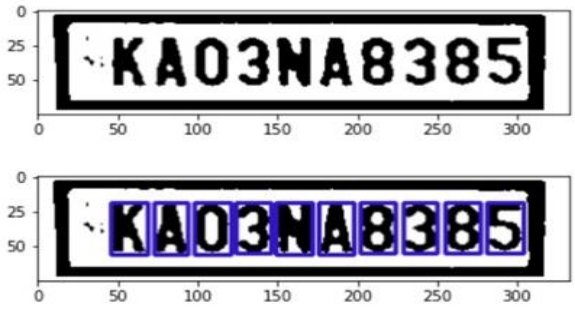

Fig 10. Extracted Plate.

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Fig 11. Pre-processed Segmented Image.

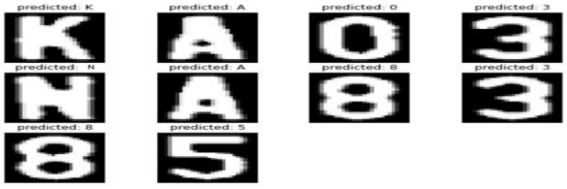

Fig 12. Recognized Characters.

VI.CONCLUSION

This project is based on deep learning for vehicle number plate detection and recognition. It majorly focuses on detecting and recognizing Indian vehicles license plate which is the single-line type where the segmentation is done from left to right on registered state, registered RTO code, unique license plate number respectively. Real Indian vehicle images for this project are being collected with various angles of orientation.

The input image is detected and segmented using YOLOv3 which works with OpenCV then the scaled image is trained on the CNN model after that image is recognized using Keras which works on the top of TensorFlow. As per the research, the accuracy of the project tends to be very high. This project can also be integrated with a database for fetching detailed information about the vehicle and powerful hardware for efficient vehicle monitoring can be used to reduce crimes and conduct traffic safety enforcement.

The challenges in this project are license plates partially covered by improper frames which hid some of the details even when viewed with a human's eye and few license plates with fancy fonts which resemble alphabets. Thus, for these cases, the model will be further trained with more datasets of a similar kind to overcome the challenges and achieve high accuracy in the future.

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