Recognition of High-Security Registration Plate for Indian Vehicles

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***Abstract*—All vehicle owners must fix a High-Security Registration Plate (HSRP), under regulations of the Delhi Transport Department and Ministry of Road Transport and Highways (MoRTH), because it is more secure than old registration plates and tamper-proof. The government is taking this measure to deter theft, standardise the font and size of registration plates to make them simpler to recognize, and easily track the owner details of vehicles. In 2020, according to the National Crime Report Bureau (NCRB), data showed that over 1.3 lakh individuals lost their lives on Indian roads, earning India the dubious distinction of being the country with the highest number of fatalities in road accidents worldwide. The proposed model is implemented to detect a high-security registration plate placed on a vehicle and then recognise the character written on it. Many algorithms have been applied to recognise the characters of registration plates, but a dataset for high-security registration plates was lacking. As a result, a dataset consisting of 500 images is gathered and analysed to create this new model. In order to annotate the data, an image annotation tool is used. The model is built using a pre-trained model, You Only Look Once version 5 (YOLOv5), for registration plate detection and EasyOCR for optical character recognition. The proposed model obtained an accuracy of 100% for detection and 80% for recognition as compared with the state-of-the-art methods.**

***Index Terms*—YOLOv5, High Security Registration Plate, EasyOCR, Optical Character Recognition**

I. Introduction

There is an urgent need to upgrade the country's vehicle monitoring system due to the considerable increase in the count of vehicles on Indian roadways over the past few decades. According to a paper presented by Poonji Jain et al. [1], hit-and-run accidents account for over 30% of road accidents in India, but only 10% of the drivers involved in these accidents are detained. This is because sometimes it may be challenging to observe drivers who violate the law and occasionally drive too fast. In addition, it's estimated that about 100,000 cars are stolen in India every year. As the economy improves and more people are able to purchase vehicles, this number will only increase. Also, old registration plates are quite simple to tamper with and may be pulled out or switched around quickly; hence, the Indian government has been mandated to fix HSRP.

High-Security Registration Plate (HSRP) comprises a hot-stamped chromium-based 20 mm × 20 mm hologram of blue colour on the top left corner and a 10-digit permanent identification number (PIN) that is laser engraved on the reflective sheet as shown in Fig. 1. The HSRP comes with a stamped film applied to the registration numerals and letters bearing the inscription "INDIA" at a 45-degree angle. Once the unique registration is fixed, it is then electronically linked to the vehicle. Unlike the old registration plates, the font and style have been kept the same. The HSRP is highly secure because it is challenging to replace and comes with a non-removable snap-on lock. The HSRP number is advantageous because key information about a vehicle, such as the engine number and chassis number, is kept in a central database. The stored data, along with 8 to 10 character PIN, becomes crucial in identifying a stolen vehicle. The HSRP number is always unique and can only be issued by the government. This has successfully reduced the number of vehicle thefts in India.

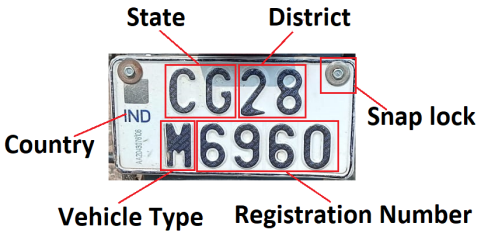

Fig. 1: HSRP format

Therefore, it is feasible to build a system that can effectively monitor vehicles and extract the text from their registration plates in order to provide an efficient solution to this problem. In recent years, deep learning methods have largely replaced most statistical methods in computer vision systems due to their excellent object detection accuracy. In this model, registration plate detection is accomplished using the efficient object detection method. Techniques for image preprocessing are employed before character recognition for improved accuracy. In India, there are a number of challenges that must be overcome before a working prototype of HSRP systems can be created. The first problem arises due to the different colours of the vehicle's registration plates. Registration plates can be used to designate the vehicle's intended use; for example, a black and white plate indicates a private vehicle that may not be used for business purposes, while

a yellow plate indicates that the vehicle may only be used for business purposes. The inadequate infrastructure of India's traffic control system is another pressing problem on indian roads. Due to environmental variation, it can be challenging to detect the registration plate. The use of low-cost, poor-quality cameras with limited visual coverage and slower motion, which commonly produce blurry or low-resolution images, is another significant issue.

A. Motivation

Many aspects of human existence are continually being transformed as a result of technological advancements such as smart cities, smart automobiles, and smart transportation systems. Because of this, technology such as the automated identification of registration plates has become ingrained in the way we go about our everyday lives. In addition, the HSRP recognition system is a promising idea that can make important contributions to a wide range of applications where human interaction is unnecessary. This model is the most precise use of computer vision and image processing. The vehicle registration plate text will be read with the use of optical character recognition (OCR) in the models used by HSRP recognition systems. Images of registration plates are sent through image processing techniques, which then utilise character recognition and segmentation algorithms to decipher the plate's textual content and sequence verification checks to ensure the accuracy of the captured pictures.

B. Research Contribution

The major contribution in this paper can be pointed out as follows:

- Detect the registration plate placed on a vehicle and then extract the text of the registration plate.
- Propose an efficient model that can be used for vehicle surveillance.
- Make a local dataset by collecting images of the high-security registration plates of Indian vehicles.

Following are the sections that are presented: Some of the existing research on registration plate recognition systems is discussed in Section 2. In Section 3, background details are discussed. In Section 4, the proposed work on the new HSRP dataset is outlined. In Section 5, the numerical evaluation and prediction results are shown. The paper is concluded in Section 6, which also discusses future work.

II. Related Work

In the field of licence plate recognition systems, numerous studies have been conducted. The majority can be classified as having different plate detection, character segmentation, and character recognition algorithms. The development of an automatic licence plate recognition system has been a hotbed of academic activity in recent years. In 1976, the United Kingdom created the first automatic number plate recognition system to aid in the battle against crime. After then, a plethora of new algorithms were developed specifically to enhance the precision of such systems.

In 2022, Vaishali et al. [1] used OpenCV for registration plate detection and optical character recognition for character recognition and segmentation processes. For the vehicle counts, the author used a background subtraction technique that detects moving objects in a string of still camera frames. Hemant Kumar Giane et al. [2] outlined a method for creating a HSRP licence plate identification and number recognition system that is intended for use in a variety of applications. The author used MATLAB to implement this model. The model is evaluated on 100 different images, and the success rates for plate placement and character identification are 98% and 99%, respectively, demonstrating the excellent efficacy of the strategy. The two most often used OCR techniques are Tesseract OCR and EasyOCR. EasyOCR performs better than Tesseract OCR in terms of speed and accuracy while reading licence plate numbers [3] . The outcome demonstrates that EasyOCR has achieved greater than 95% accuracy for number plate prediction as compared to Tesseract OCR, which has only achieved 90% accuracy. The authors [4] have discussed a number of vehicle theft and traffic accident difficulties and challenges that can be resolved with the HSRP. 22 research studies focusing on HRSP plate detection have been investigated, and they have given an overview of the related literature. A model for detecting the licence plate has been put out that makes use of Python and OpenCV.

In 2022, Gayatri Hajare et al. [5] have proposed a method based on YOLOv5 for the detection of number plates and used Google Tesseract for the recognition of the same. During preprocessing, they have applied transformation method for converting RGB raw image into its corresponding grayscale image. Further, the morphological operation is performed for image enhancement and then licence plate recognition is accomplished with the aid of closing and opening morphological analysis along with canny edge detection. In 2021, K. Prema et al. [6] used an annotated dataset for registration plate detection. They have used LabelImg for this task to label the data in such a way that the input image has a bounding box around the registration plate to aid in detection. YOLO model is used for character segmentation and recognition. The YOLO model has a character recognition accuracy of 95%, whereas the OpenCV model has an accuracy of around 93%. An automatic number plate reader system was proposed by Naren Babu et al. [7] which consists of two stages: detection of the registration plate and optical character recognition. The authors have trained a CNN-based single YOLO model with the help of 37 class for both recognising the characters on the registration plate and detecting the registration plate itself. They have also reached an accuracy of 100% when detecting the number plate and 91% of accuracy when recognising the characters on the registration plate. In 2017, Maulidia Rahmah Hidayah et al. [8] proposed a method that demonstrates both the implementation and accuracy of K Nearest Neighbor (KNN) algorithms and Otsu. Otsu is a technique for converting RGB images to binary images and for extracting picture attributes. Otsu method is used for feature extraction, and KNN method classifies data by comparing it with training data.

III. Background Details

Computer vision plays an important part in the processes of detecting objects, tracking objects, and recognising characters. It also has a variety of applications in real life, one of which is the recognition of vehicle registration plates.

A. Computer Vision

Computer vision is a subfield of artificial intelligence (AI) that enables computers and systems to gather pertinent data from images, videos, and other visual inputs and to take appropriate actions or make suggestions in response to that data. Computer vision gives machines the ability to perceive, observe, and grasp the world, much like artificial intelligence gives them the ability to think. It can be used to find specific objects in images, search through collections of images, and extract information from images, among many other things.

B. Object Detection

Computer science's field of object detection is strongly related to computer vision and image processing. This subfield of computer science is dedicated to the task of identifying digital images and videos for the presence of specific classes of semantic objects. Face recognition and pedestrian detection are two subfields of object detection that have received extensive attention. Object detection is useful in a wide variety of subfields of computer vision, including image retrieval and video surveillance.

C. Character Recognition

Character recognition is one of the optical information processing applications that eloquently displays the parallel processing capacity of optical systems. This is a particular instance of the "pattern recognition" category of processes. In pattern recognition, the locations on an input data page where a specific pattern appears are identified. In character recognition, it is important to find a specific character or word on a page of input text. One method for conducting this search is to employ matching filters.

IV. Proposed Work

The proposed system is divided into four different stages, as shown in Fig. 2 to comprehend the system's operation effectively. The first step is to gather images for the dataset of high-security registration plates from various types of vehicles, such as cars, bikes, etc. Then, images are labelled for object detection of the registration plate using an image annotation tool. In the proposed system, the YOLOv5 model is used for registration plate detection. This detected registration plate is segmented for further detection. We are using YOLOv5 rather than an older version of YOLO, in contrast to its predecessor. It is better to recognise smaller objects during the training phase. After the process of character segmentation, the system then makes use of EasyOCR to recognise the characters that are present on the registration plate. EasyOCR enables a programme to recognise texts or words written in a user's oral communication without the need for human participation.

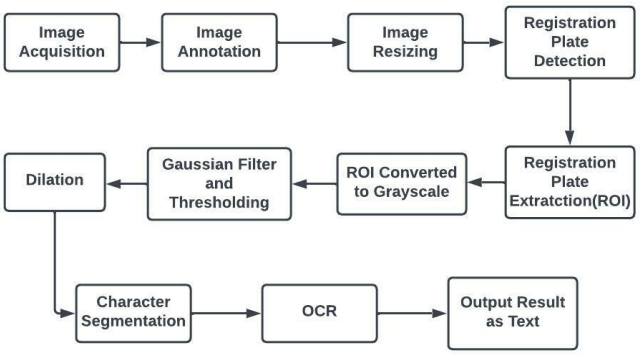

Fig. 2: Workflow of proposed model

The proposed method can be divided into the following stages:

1) Image Acquisition and Annotation
2) Registration Plate Detection using YOLOv5
3) Registration Plate Extraction
4) Registration Plate Character Recognition (OCR)

A. Image Aquisition and Annotation

Due to the lack of a dataset of high-security registration plates, around 500 images of various Indian vehicles, including bikes, cars, and others, with both front and back views is collected to create our local dataset. It comprised of various images of vehicles found on the internet, as well as images acquired from mobile devices, as shown in Fig. 3. The dataset includes images from several Indian states.

To label images manually, a graphical image annotation tool named LabelImg is used to recognise the bounding box for the registration plate. It has a graphical user interface and is written in Python with the Qt framework. When we launch it, a graphical user interface opens, and we need to click the CreateRectBox button to create a bounding box and save the output as an XML file compatible with the YOLO standard.

Fig. 3: Image acquisition of the vehicles

B. Registration Plate Detection using YOLOv5 model

For the detection of registration plates, an object detection technique called YOLOv5 is used, which was released by

Ultralytics in June 2020. It is now the most powerful object detection algorithm in this field. This technique uses a single neural network to process the full image before segmenting it and producing bounding boxes and probabilities for each individual section. Predicted probabilities are used to assign weights to these bounding boxes. Since the method only performs a single forward propagation loop in the neural network before producing predictions, the image is only examined once. To ensure that the object detection algorithm only detects an object once, it uses non-max suppression before sending out the results.

The CNN-based YOLOv5 model is used for real-time data gathering. It is proposed to use this method to obtain a registration plate for a vehicle. CNN is capable of rapidly analysing received images and discovering recurring patterns while retaining a high level of accuracy. The YOLOv5 algorithm is utilised to detect and locate many kinds of objects with the help of TensorFlow library, which is mostly found in Python. The registration plate detected using YOLOv5 is shown in Fig. 4.

Fig. 4: Image after registration plate detection using YOLOv5 Model

C. Registration Plate Extraction

The next crucial step in identifying a registration plate is segmentation, which separates the plate from the source image before applying optical character recognition. In this step, the region of interest is cropped as shown in Fig. 5, which will then be sent as an input to OCR.

Fig. 5: Region of Interest(ROI)

D. Character Recognition of the Registration Plate using OCR

1) Image Preprocessing: Image preprocessing techniques are used sequentially in this model to enhance the region of interest prior to sending it through OCR, as shown in Fig. 6.

- RGB to Grayscale Conversion: Converting a picture into grayscale is necessary since colour images do not aid in the identification of critical edges and other features.
- Gaussian filter: It is a low-pass filter, and its purpose is to minimise noise in an image while also blurring specific parts of it.
- Image thresholding: Based on pixel intensities, it is used to binarize the image. The model employs the automatic global thresholding approach known as the OTSU thresholding method.
- Dilation: Dilation adds pixels to object borders while also enlarging the image's pixel count.

Fig. 6: ROI after image preprocessing

2) Character Recognition: Character recognition is the final step of registration plate recognition, and it involves employing optical character recognition (OCR) to determine the individual characters that are spaced out inside a text format, as shown in Fig. 7. In this model, EasyOCR is used for recognition. It is developed using Python and Pytorch deep learning framework. The Computerized Relative Allocation of Facilities Technique (CRAFT) is used for the detection portion, and the convolutional-recurrent neural network (CRNN) model is used for recognition.

Fig. 7: Output after performing OCR

V. Results and Discussion

After training the model using YOLOv5, a very high amount of accuracy is achieved in identifying the registration plate. The accuracy of the plate detection model is 100% as calculated from confusion matrix in Fig. 8. The graphs of precision, recall, training loss, validation loss, and mean average precision (mAP) are shown in Fig. 9 after 100 epochs. The result of our approach for recognising the registration

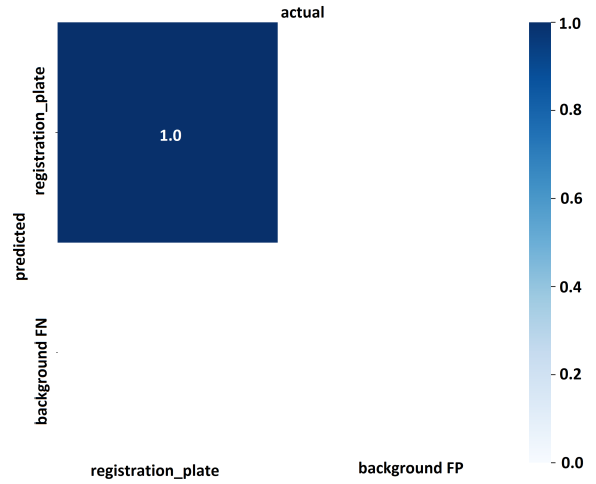

Fig. 8: Confusion Matrix for plate detection using YOLOv5

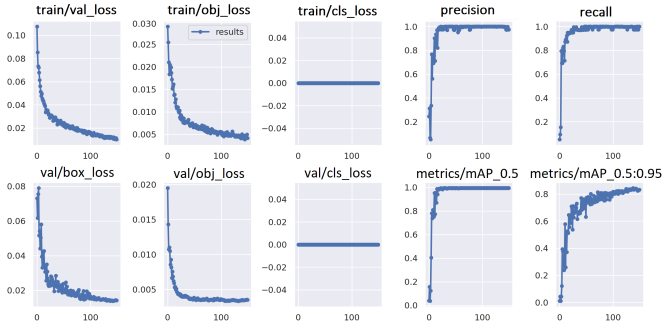

Fig. 9: Result of detection model using YOLOv5

number on various images of vehicles are shown in Table I and Table II. We have gathered images of vehicles from Odisha, Bihar, Uttar Pradesh, Chhattisgarh, and other states as well because our model is specifically designed for Indian vehicles. The registration number that has been detected by the proposed model is displayed in the table below. Our analysis shows that when images are highly blurry, hazy, and small, the model frequently fails to recognise the text.

Table I. Analysis of result on successful cases after performing OCR

Region of Interest(ROI)	Actual Registration Number	Predicted Registration Number	Result
	KA42N2683	KA42N2683	Correct
	HP33F33815	HP33F33815	Correct
	OD14Y9190	OD14Y9190	Correct

Table II. Analysis of result on failed cases after performing OCR

Region of Interest(ROI)	Actual Registration Number	Predicted Registration Number	Result	Reason of Failure
	OD14X3020	————	Incorrect	Different background color
	KL01AU585	O1U585	Incorrect	Highly tilted image
	KL01AX8000	KLOTAXEOOC	Incorrect	Blur image

VI. Conclusion

The proposed algorithm is able to accurately predict the majority of Indian vehicle registration plate numbers. The object detection model that makes use of YOLOv5 has a remarkable accuracy of 100% as compared with the existing approaches. EasyOCR is used for the recognition of registration plate numbers, and its accuracy is estimated to be around 80%. This system can be used as a surveillance system that records a vehicle's image and recognises its registration number. Other uses of this system include parking management, traffic management, journey time analysis, etc. The process of vehicle registration plate recognition is being automated, which saves time and money. Further, the task of real-time application of this technology can be accomplished in the future.

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