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An Imperious Verdict for The Recognition of Vehicles Number-Plate Using an Innovative Methodology

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***Abstract*—Non-standardized number plates are prevalent in India's present traffic patterns. Vehicle number fixed-plates should be perceived and systematised for a great number of reasons. Authorities have a tough time identifying and tracking down a specific car. In a growing nation like India, setting higher restraints on the effectiveness of any licence plate identification and recognition algorithm is impossible. The major goal of this study is to develop a method for detecting and identifying India's transitional vehicle licence plates. Using single or multiple state-of-the-art automation, including machine-learning models, the character identification efficiency of drawn and printed plates in diverse styles and fonts improved dramatically. From a range of licence plate data, the proposed technique can develop rich feature representations. To find the licence plate in the appropriate location, the input image is first preprocessed to decrease noise and increase clarity, then separated into appropriate-sized grid cells. After the YOLOV5 has been trained, the licence plate characters should be appropriately divided. The three-character recognition systems OCR, LSTM, and STR are compared and contrasted in this study, with the conclusion that STR is the most accurate of the three. Finally, the data is post-processed, and the proposed model's accuracy is tested against industry benchmarks. Vehicle monitoring, parking fee collection, detection of automobiles violating speed limits, reducing traffic accidents, and identifying unregistered vehicles are all expected to benefit from the proposed system. The results reveal that the suggested method achieves plate detection and character recognition accuracy levels above 90 percentage.**

***Keywords*-Object Detection, Image Processing, Transfer Learning, YOLO, Deep Learning, OCR, LSTM, STR**

I. Introduction

Intelligent Road Transportation systems can pave the way for safer journeys on the roads. A major challenge associated with this is automatic number plate recognition. The ability to automatically detect and recognise number plates accurately would solve many problems associated with traffic systems. It could also find application in implementation in different areas like law enforcement, smart parking lots, and could even replace the existing RFID system in tolls as each vehicle passing through a tollgate would have a number plate for sure. In developing countries like India, emendation is to be brought in to prevailing number plate detection techniques.

The two major challenges faced by existing systems are inefficient bounding box detentions made by old algorithms and the ambiguity in the recognition of some alphabets and numbers while the resultant part of the image in the bounding box is fed to an OCR (Optical Character Recognition System). Here we make use of the YOLO (You only look once) V5 algorithm, which is 88% smaller and 2.5 times faster than its previous V4 version. Yolo algorithms outperform most other object detection algorithms, and thus their latest version is more than enough to get a good bounding box with the best IOU (Intersection over Union). And thus, our first challenge is solved. All number plates in India are alphanumeric. The first two characters of the registration number would be two alphabets that represent the state, followed by two numeric characters. Then there will be a few series of alphabetic characters and at the end four numeric characters. Our approach is to train two models, one for alphabets and the other for numbers, using LSTM for recognition on the number plate. We have used STR, which addresses irregular cases in our lives, such as curved or perspective texts, occluded texts, texts in low-resolution images, and texts written in difficult fonts. We can directly pass the cropped output of the YOLO model to the STR model for recognizing characters without any further work.

II. Related Works

Computer vision's main goal is to develop artificial perception systems that are comparable to, if not superior to, human performance. Computer vision creates a connection between the digital and physical worlds. Most computer vision applications rely on image and video descriptors. The fundamental features that are required for road traffic governance are management, surveillance, and control. In

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this study, photos captured by cameras are used to detect objects. Images for computer vision are collected using a digital camera.

During the previous two decades, the widespread usage of personal vehicles has presented a number of issues, including efficient traffic control, tracking traffic rule breaking vehicles, locating stolen vehicles, and security surveillance. These duties necessitate the detection and recognition of vehicle license plates. As a result, there is a significant amount of literature devoted to the recognition of license plates.

The primary and most important stage in number plate recognition is the successful extraction of plate images from an image or video of a vehicle on road. For achieving this [8] used the advantage that the area in which vehicle license number plates lie has high contrast areas in an image black-and-yellow or black-and-white. In license plates, the alphanumeric characters are placed vertically in the same line and vary in intensity horizontally. The alphanumeric characters and background in an image have a sharp variation in intensity; it will help for detecting the license plate region. They have used the Sobel edge filter to identify the boundary of the license plate and with those coordinates crop out the plate from the image.

Akram AL-Hadad, Hazem M. El-Bakry & Reham R. Mostafa [1] also similarly used the Sobel operator to detect edges as it is easy and also less sensitive to noise, but they have only used vertical mask. They have reported an accuracy of 92.2 percentage on 464 colored images with this approach.

Slimani, I., Zaarane, A. & Hamdoun [11] used the Connected Component Analysis technique to extract the number plate from the image but this approach fails as noise in the image increases. [7] used LPR-SSD network architecture. Five convolution layers and one max pooling layer make up their feature extraction layer. The feature map produced by each convolutional layer is used to offset the default box and estimate the scores for various license plate categories. To achieve multi-scale detection, training and prediction of license plate position and categorization are performed on these feature maps.

The next step following number plate localization is character segmentation for these commonly used approaches are: Pixel connectivity is used for segmentation in [2,3]. In [3], 958 High-Definition images with various conditions are tested using connected component labeling, This system gave an overall accuracy of 93.7%. For scene text recognition [4] looked at the discrepancies in training and assessment datasets, as well as the performance difference that comes from these inconsistencies, in order to design a framework. This approach enables a thorough examination of previously suggested STR models as well as the discovery of previously unknown model combinations. The proposed framework was a four-stage STR framework into which most existing STR models fit.

III. Methodology

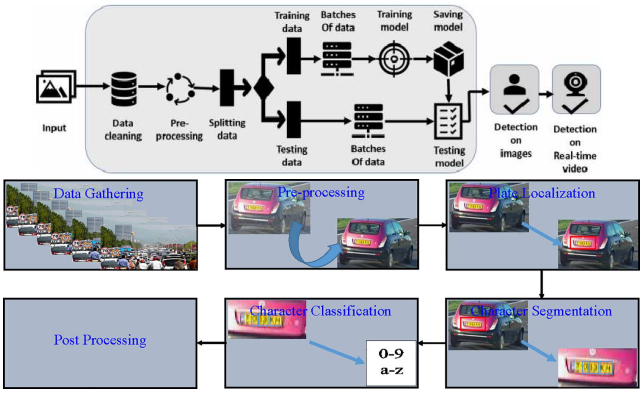

Figure 1. Overall detection and recognition architecture

A. Data Gathering

We have collected different images of Indian vehicles from Kaggle [12] and also some from google images [13]. In order to feed it to Yolo for training, we had to mark the bounding boxes of license plates in the image and label them. For that, we had used Roboflow (https://roboflow.com/) to annotate our dataset and this online tool also helped us to augment images with different filters.

For character recognition, we have got a dataset with binary images of characters [13] and numbers we had to manually separate out numbers and alphabets to split it into two different datasets.

B. Pre-processing

Different preprocessing techniques were employed at the initial stages and also at the segmentation phase. Initially, we had to resize the input image to feed into our model for plate localization. After obtaining the number plate for segmentation, the cropped image is then extracted value channel from HSV format by applying adaptive thresholding to reveal characters on the license plate. Also, the CLAHE mechanism is used to increase the contrast of the image to be segmented. Erosion and dilation methods helped us to remove noise from the image but we found out that this approach is a bit risky as characters like 'N' which have a much thinner connection between two vertical lines are separated.

C. Plate localization

For plate localization we first tried out using VGG-16, the convolutional neural network model proposed by K. Simonyan and A. Zisserman [6] but it was not accurate enough in determining bounding boxes (results are shown

in figure 2). Here we can see that bounding boxes are not at exact corners of the license plate only perfect close images are recognized with greater accuracy. With this model, we can't work with real-world datasets.

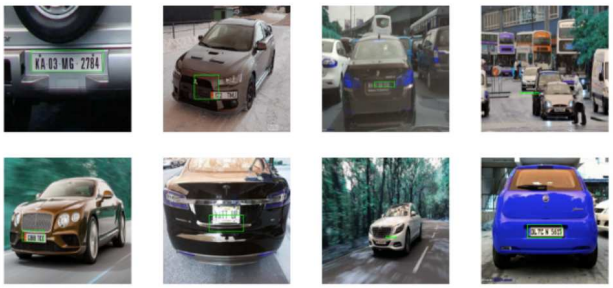

Figure 2. VGG-16 output

Our next approach was to make use of the YOLO [5] (You Only Look Once) algorithm which is getting popularity now for object detection. The latest version of YOLO (Version 5) was used here. YoloV5 algorithm was found to be 2.5 times faster and 88% smaller than its previous version (YOLO V4). We have trained our annotated dataset of car images for 300 epochs and got mAP (mean average precision) of 0.9821 and precision of 0.97902. The resultant metrics of training are plotted in figure 3.

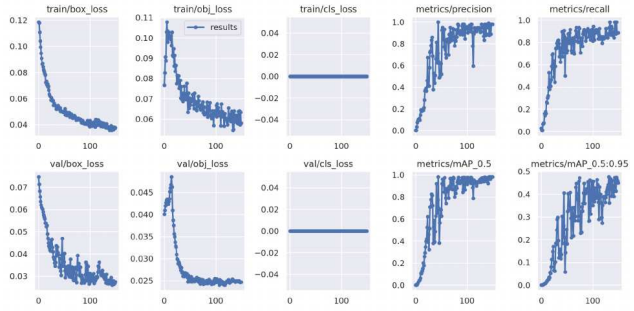

Figure 3. YOLO training metrics plot

Yolo algorithm was way more accurate than VGG 16 and all other techniques based on Image Processing in successfully localizing the number plate region from a video or an image of a vehicle. Some cropped results from YOLO output is shown in figure 4

D. Character recognition using OCR

After localization, we could use different OCR techniques to read and extract registration numbers from the resultant image. Most researchers, even we have tried tesseract OCR for recognizing characters. But this approach will not succeed in most scenarios. Number Plates must be incorrect augmentation and there should not be any noise also the font and character size plays a key role here. Most of the real-world images fail in this approach.

Figure 4. YOLO cropped output

E. Character segmentation

After successful localization of license plate, next comes the extraction of each character for individual recognition of characters. The above used YOLO algorithm can again be used by training it once again by annoying each and every character in the license plate dataset and labeling it with respective alpha-numeric values. This is an easy and accurate method but here while each character could be segmented and classified with great accuracy, the order of classification will be sometimes uneven. So it is better if some Image Processing Techniques are employed for segmentation.

We have used here Open Computer Vision (Open CV) library to process the image and segment it into characters. After performing the image preprocessing mentioned above, for contour detection, we have passed RETR_TREE as an argument in v2.findContours function and selected only those contours which are of a size bigger than 1/200th the area of the image, or which are no bigger than half the size of the image. Also further we selected contours of height not less than 1/5th of the image height, and width not more than 1/5th of the image width. We also tried to remove the inherent noise in the given number plate. Cases where one contour was inside another contour like 'O', '0', 'D'.etc were also taken care of.

F. Character classifiation and recogntion

For classifying characters with more accuracy, while passing the segmented characters to any traditional algorithms trained on a dataset of characters, we found that the model gets confused while classifying ambiguous characters like '0', 'O', 'D',' Z', '2' .etc. We tried to solve this issue by training two separate models, one for alphabets and the other for numbers. Every country has a format for the license plate. In India, the first two characters will be alphabets followed by numeric and the last character will always be numeric. This pattern in the number plate can be utilized for getting more accuracy by only using the respective alphabet or numeric classification model for respective positions. We have trained the alphabet and numeric models using LSTM (Long Short Term Memory) [9], which is a type of recurrent neural network and it provided us an accuracy of 95.81%.

G. Character recognition uisng STR

Detecting text regions in scene photos and recognizing the text in the regions are the two main tasks in reading text in natural situations. Scene text detection (STD) is the former, and Scene text recognition is the latter (STR). Unlike optical character recognition (OCR), which focuses on reading texts in clear documents, STR can read curved or perspective texts, obstructed texts, messages in low-resolution images, and texts written in problematic fonts. We can directly pass the cropped output of the YOLO model to the STR model for recognizing characters without any further works.

STR is performed in four main stages which include: Transformation: Here Spatial Transformal Network or STN is used to transform the curved text into normalized horizontal text. Feature extraction: Here we make use of ResNet for extracting visual features from the transformed image. Sequence modeling: Bidirectional LSTM is used to convert the visual features into contextual features. Prediction: Connectionist Temporal Classification decoder is used to predict the character sequence.

IV. Conclusion

ALPR applications are becoming increasingly complex in the Indian context with the phenomenal exponential growth in the car, two-wheeler, and auto industries. ALPR applications like automatic toll collection, automatic charging systems in parking spaces, management vehicles in parking spaces, traffic monitoring, etc., have posed new research tasks in ALPR with newer dimensions. We have developed a technology for automatic license plate detection and character recognition by taking inputs from images or live video feeds. Our technology uses 2 methods for character recognition:

1) LSTM: LSTM (requires segmentation) Character segmentation has been implemented on extracted number plates. Finally, segmented characters can be recognized by using LSTM.

2) STR: STR focuses on reading text from extracted number plates. While comparing STR model used here over LSTM, we found out that STR was way more accurate in recognizing characters in numberplate detected by YOLO.

We hereby conclude from out work that through combination of YOLO V5 for numberplate bounding box detection and STR instead of traditionally used OCR for character recognition, we can get best results within limited time even without using any complex character segmentation approaches.

V. Limitations

The camera should be of medium quality, Otherwise, correct text from the image would not be extracted properly. There should be proper lighting. This system does not respond properly under different illumination conditions. Although accuracy is high, mean squared error leads to low computational results.

VI. Future Enhancements

The proposed system's implementation can be expanded to recognize numerous vehicle number plates in a single image frame. User-friendly android applications can be developed for traffic surveillance management systems. Also, character recognition can be done using various other deep learning algorithms as they yield more accuracy. In countries having strict number plate formats like 'CCNNCCNNNN' (C- Character, N - Number) Character Classification approach would be more effective and accurate. India has recently introduced BH numberplate with a common format all over the country. If this is made mandatory, then Character Segmentation approach mentioned above will be easier to employ all over the country.

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