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An Intelligent Approach for Miscreant Vehicle İdentification with Automatic Notification

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***Abstract*— The rapid urbanization has witnessed exponential growth in the vehicular movement, becoming difficult for the authorities to verify insurance details, traffic violators and tracking stolen vehicles on the road. The proposed work captures the vehicle registration plate image using a standard resolution camera for detection and recognition using a Deep Neural Network text detector model. The feature extraction of this framework is enhanced by a faster R-CNN version for scene textual data called PVANet. Automating the detection, recognition and notification of miscreant vehicles could ease the cumbersome process of tracking vehicles in signals, toll booths, private and government restricted areas. The registration number extracted is then cross-referenced using RPA, with the data provided by the insurance company and police department to identify defaulters with automatic notification to the concerned authorities without any human intervention.**

***Index Terms*— number plate, deep learning, scene text detector, robotic process automation, defaulters tracking.**

I. INTRODUCTION

With the increasing population, the vehicles on road are also increasing. The surge in vehicular movement invariantly poses an uphill task for authorities to track violators [1]. The motor vehicle registration is a unique identifier for the government database and tracking. It facilitates government authorities and police to track violators, tax, insurance, toll payment defaulters and stolen vehicles. The license plate consists of which country it belongs to, which state the car was purchased and unique number for each vehicle. Every country has its own type of serial numbers. For example, in India, MH 05 AG 0000, here the first two letters define the state, the second two numbers define the precinct it belongs to and AG 0000 is the unique number given to the vehicle. This unique number plate detail help in the tracking stolen vehicles and violators at junctions, parking areas and restricted locations which are monitored by cameras. Insurance defaulters and toll booth payments.

Artificial Intelligence (AI) fosters the creation of intelligent machines that mimic the cognitive capabilities of humans through computer-based techniques. At the outsetAt the outset, Deep learning models offer better solution and flexibility through its learning capability of real-world applications through human brain structures.

Robotic process automation (RPA) compliments business process automation with metaphorical software robots (bots) or digital workers. RPA emerges as a software-based solution to automate rules-based business processes that involve routine or mundane tasks that are structured, semi-structured or unstructured. Survey reveals that RPA accelerates productivity, costs and further reduces error as there is little or no human intervention. Thus, RPA based software comes as a boon to this rapidly urbanizing era. UiPath is a leading Robotic Process Automation vendor on Cloud to automate repetitive and mundane business processes.

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II. BACKGROUND

An extensive number of approaches and methodologies have been proposed for vehicular license plate identification and recognition using Artificial Intelligence types. The literature relevant for the proposed work is described in the following sections.

Optical character recognition (OCR) detects potential characters from optical signals or digital images. Scene text detection on the other hand detects regions with words [2, 3].

Literature reveals that scene text detection usually adopts anchor or bounding boxes to capture the real-world object based on the aspect ratio [4]. Automatic Number Plate Recognition System [5] fosters detection, segmentation, and recognition. It can actually detect the number only if the image is captured by the ANPR camera in the appropriate angle with no blurring. The first step of the process is to capture the number plate by the ANPR camera. This is followed by the detection, segmentation and recognition of the characters. ANPR system uses algorithms such as Image binarization, Edge detection, Hough transform, Blob detection and Connected Component Analysis for the segmentation and the recognition of the characters in the captured number plate image. ANPR system has its own flaws wherein it cannot detect the number plates if the image has no clarity and is tilted.

Vehicle Number Plate Recognition and Extraction using Optical Character Recognition [6] consist of four basic steps. The first step is to acquire images using any camera device of any resolution. The second part is to extract the character, followed by converting the RGB image into grayscale, followed by image binarization and filtering of the noises from the image. The third major step is to pixelate and segment the image for the acquisition of the character from the number plate. Finally the characters in the image is scrapped using the OCR available in the MATLAB platform, to produce the output. However, the usage of OCR alone for the extraction of characters is less efficient and also more time consuming. Thus, a more efficient system has to be produced for the high-speed recognition.

Vehicle Number Plate Detection System for Indian Vehicles using neural network [7], has three major steps such as pre-processing, extraction from region of interest followed by character recognition. Firstly, the image acquired is pre-processed by converting the RGB to grayscale, then the noise from the image is removed and the image is converted to binary data. Secondly, segmenting the characters identified in the image and generating temporary label for the characters is done. Finally, character by matching using normalized cross-correlation is done to produce the text-based output.

Smart Vehicle Number Plate Detection System using improved segmentation for number plates belonging to various countries [8] proposed has five major steps. The first one is to acquire image using any device of any resolution and converting the RGB image into grayscale format for further processing. The third step is to detect the vehicle number in the extracted image using the trained model. The fourth and important process is the segmentation process of the trained image model. If connected components are identified then, a special label values are assigned. The last step is to recognize the text in the image. However the conclusive results reveal that mere improvement in segmentation alone cannot extract and recognize the characters in the number plate effectively.

Automatic License Plate Detection and Recognition using Deep Learning [9] has three steps for detection and recognition. The work focuses on command force, parking system and road safety. This work begins with the detection of the number plate using deep learning object detection architecture with Convolution neural network, which further performs a regression task of predicting both the object's bounding box and its' s. It works on 45 frames per second. The second step is to segment the license plate which will be able to extract the uni-character images. It uses the histogram of pixel projection helps in producing horizontal and vertical lines in the identified image thus extracting the white objects present in the image, identifying the characters. The third step is to recognize the characters formed from the segmentation phase which is complimented by the learning model.

Literature survey reveals that effectiveness has traditionally been the main focus but improved efficiency has been neglected especially from the perspective of the memory usage, inference time to name a few. Motivated by the findings in literature, the proposed work uses the Deep Learning, text scene detector approach to extract vehicle number plate details. The use of Robotic Process Automation to check the vehicle details and notify vehicle defaulters to the concerned authority via SMS, further complements this work.

III. DESCRIPTION

Detecting and recognizing license plate details become more complicated when it comes to the font and style, with each and every country having their own style and font for vehicle number plate [9]. For example, in the Indian subcontinent the number plate size varies for two-wheelers and four-wheelers, similarly the background concept

of the number plate is also different for private vehicles, commercial vehicles, foreign delegates and government vehicles [10].

A. Project Basics

Efficient and Accurate Scene Text Detector known as EAST algorithm [3] comprises of three branches as shown in figure 1 for scene text detection. The first branch is used for feature extraction, next branch for feature merging and third branch to output the text. The learning framework uses PVANET [11], a deep lightweight Neural Network for detecting, recognizing and extracting number plate using EAST algorithm. One of the striking features of PVANet is an R-CNN feature extraction capability with lesser number of channels but with more number of layers. This PVA-Net is pre-trained model comprising of 7 filters, 16 hidden units, with the scaling factor of 2. For feature extraction the feature maps are pooled. In the merging branch, the last stage feature map serves as the input to the unspooling layer, it is doubled and concatenated with the current feature map. Finally, the 3X3 output layer merges the data. The output layer comprises of Convolution related operation for a single channel that holds the score map. At the outset, the output of the EAST algorithm can either be RBox or QUAD geometry.

In the RBox geometry, 4 channels are used to represent the pixel locations in top, bottom, left directions of the bounding box along with one channel for the rotation. Similarly, QUAD represents the coordinate shift from 4 corners of the bounding box. Here each distance offset contains 2 numbers and hence a total of 8 channels for the geometry output. Finally for the text recognition, non-maxima suppression merging via imutils package is done, where Non-maxima Suppression (NMS) is a Computer Vision related task to select a single bounding box from the overlapping ones. NMS selects the bounding box with the highest score. One of the striking features of the EAST algorithm is that this model is a fully-convolutional neural network adapted for text detection and eliminates the intermediate steps such as candidate proposal, text region formation and word partition. At the outset, in the post-processing the steps are also reduced and it only includes thresholding and Non-Maxima Suppression (NMS) for the predicted geometry.

Robotic Process Automation is a software technology that can be deployed on existing systems without changing the infrastructure or the underlying layers. In the recent years it has gained popularity as it can perform mundane repetitive tasks with or without human intervention through front office or back-office software bots. With the realization of RPA along with AI driven strategy would pave way for intelligent automation leading to approximately 80% reduction in manual operations and 6x faster turnaround time when implemented. With the increase in traffic level, automation could be extended to monitor and store vehicle details from tollbooths and strategic locations using DNN as software bots can function 24X7 without any human intervention. RPA's capability to pull and aggregate vehicle number plate details from multiple sources could help authorities identify vehicle belonging to miscreants and defaulters efficiently, thereby reducing the time spent in collecting, compiling and summarizing large volume of vehicle data.

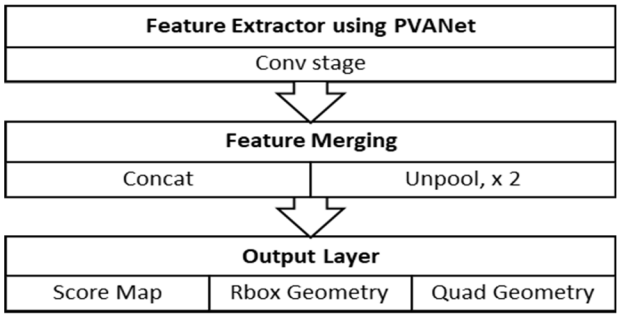

Figure 1. Basic Structure of EAST algorithm

B. Working

The proposed prototype workflow comprises of three basic modules describe below.

Number plate Detection: uses EAST text detector and PVANet Deep Neural Network models for real time object detection and as a substitution for feature extraction. It has been adapted in the proposed work as it involves less channel and more layers. EAST Text detector can predict words and lines of text at arbitrary orientations on 720p images and can run at 13 FPS. The min-confidence as Probability threshold to determine text is set with a default value of 0.5. However, EAST text requires that the input image dimensions be multiples of 32. In the feature extraction module, the new width and height is set, then the ratio in change of both width and height is compared and the image is resized regardless of the ratio.

The three layers in the East Text detector can be summarized as follows:

- *Feature extraction*: The sigmoid activation gives the probability of a region containing text or not
- *Feature Merging*: Generates the output feature map that represents the geometry of the image to derive the bounding box coordinates of the text in the input image. Then the text image is converted to a blob format
- *Output*: Number plate recognition based on the Region Of Interest (ROI) using NMS and Pytessaract for OCR operation

The first two layers denotes the Number Plate Detection and the third layer in the East Text Detector denotes the number plate recognition.

Number Plate Recognition: After detecting the scene text, the next process is to recognize the text in order to extract the number from the Vehicle license plate. The process involves, extracting ROI and scrapping the number plate. To extract the region of number plate, the layer names are supplied to net forward, which returns two feature maps. The first map is known as the geometry map and is used to derive coordinates of the bounding box of text of the given input image. The second map, namely score map contains the probability of the given region containing text.

In this phase two lists are used:

- *rects*: To store the bounding box of the text region
- *confidences*: To store the probability associated the bounding box in the rects list

Then the filtration takes place, where the text detected with low probability denoting insufficient min-confidence is ignored. For non-maxima suppression to imutils library is used for resizing the image in region of interest and eliminating, suppressing weak or overlapping bounding box using the non-maxima suppression package. The East text detector reduces the volume size of the image as it passes through the different layers in the network, hence finally the image is multiplied by four to retain the original image size. Then, the image is cropped based on the extract of Region of Interest. The number is obtained by scrapping the cropped image using Pytesseract-OCR which is known to give the best output for data scrapping.

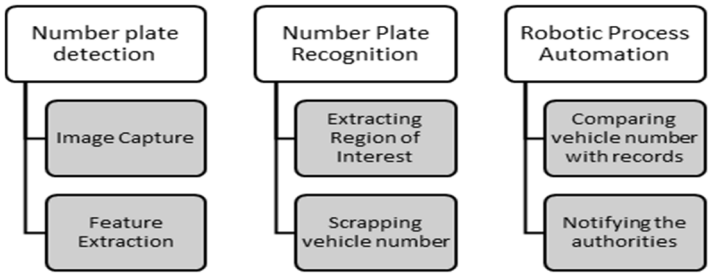

Figure 2. Summary of number plate detection for automation

RPA to verify License Plate: After the number is scrapped from the automated python algorithm, it is stored in an Excel file. Then this data is compared with the RTO authorities for insurance defaulters and the Police authorities for any kind of miscreant registered against that vehicle. After the number is extracted, the insurance company and police records details are extracted from the respective government websites using the Data Scraping activity. In the proposed work dummy government websites have been created using WebHost000 to facilitate the same. Then the data is compared using the Excel Activities Package. The Excel activities package aids users to automate all aspects of Microsoft Excel through the Excel scope Activity in UiPath studio. When the execution of this activity ends, the specified workbook and the Excel application is closed. If data does not match then there is no insurance for the vehicle or the insurance has expired. Similarly, the data is compared with the corresponding Excel file which has the police records of miscreant's details who needs to be fined. If the data matches, then the vehicle detail is that of a miscreant owner. It is followed by the miscreant vehicle number being stored in a separate excel file. An SMS via Twilio gateway is sent to the Police authorities with the vehicle number. The vehicle owner also receives a notification and a link for paying the fine amount. Similarly, the RTO officials and Police authorities receive an SMS with the list of vehicle numbers with no or expired insurance. At regular stated intervals the excel file containing the defaulter details are uploaded in the concerned authority's website as a backup option.

IV. Results And Discussion

The dataset [12] comprising of popular Indian cars number plate has been trained and tested. In this dataset vehicle number plate images from different angles, orientation and resolution of popular car brands are available. Then, a few customized vehicle number plate images of other country vehicles were also tested.

Due to the voting mechanism in the output layer of the EAST algorithm comprising of NMS procedure and Pytesseract, the proposed methodology can handle various challenging scenarios, such as non-uniform illumination, low resolution, and varying orientation in the vehicle number plate images. Moreover, this system does not rely only on ANPR system camera images as it can extract from other cameras too. The proposed trained model produced highly accurate geometry maps and score map during the output stage of the algorithm. Further, it was able to detect scene text instances of different fonts, resolutions and orientations as depicted in figure 3 eliminating the use of elaborate pipelines [13]. Above all, there is no pre-processing step involved but only post processing using Non-Maxima Suppression for Region Of Interest (ROI). Experimentation also revealed that RBOX output generates better results when compared to mere usage of OCR [14]. The usage of EAST algorithm and PVANet implementation using OpenCV, attributes for low computational cost, in contrast to the existing systems where hardware devices were also utilized to complement vehicle number plate detection applications [15]. The proposed prototype was tested with number plates belonging to different models of Audi, BMW, Chevrolet, Fiat, Ford along with customized vehicle number plate images. Figure 3 depicts images in black and white color, different fonts and different orientation, Further, experimentation reveals that the width and height of the image should be the multiples of 32. Images of width or height 320, 640 and 720 produced accurate results, while images of 480, 640 pixels width or height produced close to the actual number plate values.

The average F1-score and speed to detect, extract, recognize and notify miscreant details is tabulated in Table 1 for 300 images. The average time taken by the proposed prototype for black and white images is around 1.17 seconds and 1.2 seconds for colour vehicle number plate images. The time taken in the proposed approach is less as there is no pre-processing involved during the detection and extraction stages of the vehicle number plate images along with the reduction in additional steps for binarization or segmentation as in other Deep Learning approaches [16].

Figure 3. Sample number plates detected

Table I. Comparison Of The Existing And Proposed Systems

Performance Parameters	Existing approaches	Proposed approach
Average F1 score	0.6	17
Average time taken (Sec)	0.8	1.17 to 1.2

Table 2 summarizes a comparative analysis of the existing and proposed methodologies for vehicle number plate detection where most of the existing approaches used YOLO Deep Learning framework. Moreover, for recognition Neural Network models were used in contrast to the proposed work, where imutils package was used to identify the appropriate bounding box when there was an overlap.

TABLE II. COMPARİSON İN PERFORMANCE

Approach	Detection	Extraction	Recognition	RPA
Existing	YOLOV1, YOLOV2, YOLOV3 models	Segmentation, OCR, APIs	Multi-Layer Perceptron, K Nearest Neighbour	Not included
Proposed	EAST, PVANET models	Pytessaract	Non-maxima suppression merging	For storing and notification

V. CONCLUSİONS

Non-compliance of traffic rules and other violations has been increasing exponentially in the recent years, inspite of traffic control devices and traffic guards availability. Hence utilizing the number plate images of vehicles captured at various strategic locations such as: toll booths, traffic signal, parking area cameras, enable supervision of roadways and highway to identify miscreant vehicles, traffic violators with insurance/registration backlogs and fine defaulters. The proposed work uses intelligent RPA based vehicle number detection and recognition to notify the concerned authorities using EAST algorithm and PVANet. Extracting the number plate details from images using Deep Neural Network and automating using software bots can be performed on a routine basis repetitively to thereby manage the toll road processing, improving fines or infringements and insurance claim verification efficiently. This work can be extended for streaming videos captured by cameras in toll booths, traffic signals or other high secure areas.

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