Number Plate Recognition Using CNN For Identification Of Theft In Toll Collection System

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Abstract—An electronic toll collection system is a technology that enables automatic toll fee collection through online or offline mode from the user in a secure way. Using the image processing technique here we identify the number plate of a particular vehicle. The details of the vehicle owner (i.e vehicle number, name, phone number) will be stored in the database for paying toll fees and identifying theft at toll. Initially, we will scan the object (vehicle) using the camera placed in the toll booth it will change the captured image of a vehicle into black and white using binarization. Then the number plate is detected using CRF algorithm and the text is extracted from number plate using OCR algorithm. The data is matched with the database automatically and bill is generated without any delay. This approach also identify the theft of vehicles and real-time alert is given to the concerned persons for necessary action.

Keywords—Fixed Thresholding, Binarization, Number Plate Detection, Text Extraction, CRF algorithm, OTP Verification.

I. INTRODUCTION

Motor vehicle registration for a new number plate is done with government authority. The purpose of motor vehicle registration creates a link between the vehicle and the owner of the vehicle. This link might be used for crime detection in the case of theft and the taxation purpose in the toll booth or paying a fine for violating the traffic rules. License plate detection is used in many real-time applications such as parking systems, toll collecting systems, and security systems. It still faces many issues while using the digital camera such as in traffic detecting multiple plates, ambiguous signs, detecting other objects in the frame, and obscure images taken in bad climate or night time. These variations result in false positivity in the number plate detection and provide poor accuracy.

In our day today's life image processing techniques are used in many applications. Here, we use this technique to detect the theft vehicle in the toll booth. The surveillance camera in the toll booth captures the video and detects the vehicle in each frame of the video. Each frame will be converted into the black and white image by using the binarization technique and from that image, the vehicle object is detected. Bag of words are created from the number plate by using the conditional random field algorithm.

To solve the problems in the existing system, we propose an efficient way of license plate recognition by using Optical Character Recognition(OCR) which has a more positive rate in the result and here CNN is used for training the data for good accuracy in the result. In the OCR it consists of six steps that should be done for extracting the text from the number plate such as Image Acquisition, Pre-Processing, Segmentation, Feature Extraction, Training a Neural Network and Post-Processing. The text extracted from the number plate is matched with the database and it sends the OTP to the user for identifying the theft. Using OCR, we achieve 99% of character recognition accuracy. This method shows high performance and accuracy when compared with the traditional number plate recognition system.

a) Image Processing

Image processing is a field of study that involves the processing of images coupled with the mathematical operations. In image processing technique, input may be image or a series of images or a video. The output may be the set of characteristics or the definite attributes pertained to that image. This technique is applied to various fields like: 1. Digital Image Processing, 2. Optical Image processing, 3. Analog Image Processing. Most of the images are processed in a two-dimensional signal processing technique. Recent technologies such as computer graphics and computer vision are closely related to image processing. In computer graphics, the images are taken manually. The images are from physical models of objects, lighting,

environment, and natural scenes or some animated movies captured only through devices such as cameras or computers. Computer graphics is one of the sub-field of computer science which involves in the process of digitally synthesizing and manipulating visual content. Using computer graphics we can easily process in Two Dimensional and Three Dimensional graphics. Computer graphics are made up of pixels. Pixel is the unit of the graphical picture. Computer vision is playing a major role in the field of Artificial Intelligence. Artificial intelligence is defined as the process making a machine to think and act like a human. Simply stated as simulating a human brain. Using Deep Learning, it is easily capable for a network site to learn an environment using unsupervised learing technique from unlabeled data. Using Digital Images from videos or cameras and applying deep learning models, machines can easily identify and understand the visual world. Image Analysis is the process of extraction of Information from the digital Images using image processing techniques.The Image analysis tasks also includes reading the bar-coded tags which is analogous to identifying a person using the face. Recent advancements in image processing technology paved the way for analyzing huge amount of data. Using the human visual cortex, we can extract higher-level information and give excellent image analysis. It includes medicine, security, or some remote sensing process. It is difficult to replace human analysis by computers. The edge detectors and neural networks are image analysis tools that are inspired by perception models. In Image editing, the images in digital photographs or traditional photographs are modified. Every aspect of an Image can be altered. This Image editing technique is similar to the traditional photo retouching using basic tools such as airbrush. By this we can modify the images or apply editing illustrations with any art medium. Graphic software programs are also used to alter, modify or enhance the Images with special tools. Most images are extracted from various editing programs with the use of rendering computer art built from the scratch. Raster Images contains the picture in the form of grid elements or pixels from the computer. These type of pixels contains only Images and brightness information. The pixels can be changed as a group or Individually by only sophisticated algorithms from image editors. Many graphical applications are capable of merging one or more Individual Images into a single file. When using Raster Image which is otherwise called silhouetting is not rectangular, it separates the edges from the background. The process of clipping paths is used to add silhouetted Images or Raster Images to vector graphics. From selecting the Edges by raster tracing or consisting a path to a silhouetted selection. Once the image is selected means, it may be copied and pasted into another section of the same file or separate file. Using Transparent layers composite images are created and Using the Image layer mask, the parts of various images are merged in the background layer.

a)Steps of Image Processing:

i)Image Acquisition

It is the initial and basic step in image processing. It is a simple process in image processing because the given image is already in digital form so the process can be done easily. Generally, this process involves preprocessing such as scaling, cropping ,etc.,

ii)Image Enhancement

It is the most simple and appealing step in image processing where the given digital image became more sharpen after completing this step. The main idea behind the step is to highlight certain features in the image such as contrast, brightness, etc.,

iii)Image Restoration

Image Restoration is used for improving the appearance of an image. This step is different from the image enhancement step wherein enhancement is subjective but the image restoration is objective. The image restoration technique is purely based on the mathematical model of image degradation.

iv)Color Image Processing

It is an important process because of the increase in use of digital images over the internet. It includes color modeling and processing in the digital domain.

v)Wavelets and Multiresolution Processing

Wavelets are used to represent the image in various degrees of resolution. For data compression, images are successively subdivided into smaller regions. It is a technique to reduce the size of image or bandwidth to transmit. Bandwidth is important, because it uses the internet. It is also important to compress the size of an image.

vi)Morphological Processing

It is a tool that is used to extract the image components which is helpful in the representation and description of shape

vii)Segmentation

In which the image will be partitioned into its constituent parts or objects. One of the difficult tasks in digital image processing is autonomous segmentation. For identifying the individual objects in the image, we can use a rugged segmentation procedure which is a successful solution for the imaging problem.

viii)Representation and Description

It follows the output of a segmentation stage which is raw pixel data it will either represent all the region or the boundary of a region. Representation is a part

of a solution for transforming the raw data into a form of subsequent computer processing. Description deals with extracting the attributes and that result in one class of object from another.

ix)Object Recognition

It is the process of assigning a label for the object based on the descriptors.

x)Knowledge Base

It is a simple process, where it details the regions of image. While performing the search operation it is highly preferred to give only a limited set of attributes. It became quite complex to interrelate the major possible defects in materials or an image database containing a high-resolution satellite image of a region in connection with change-detection applications.

II. RELATED WORK

In recent years, many traffic applications like: smart security systems, smart traffic systems, smart parking systems etc., uses License Plate Recognition technology. Technological advancements enables Licence Plate Recognition (LPR) to play a major role in the development of smart cities. This LPR facilitate the surveillance system for vehicle management, investigation of theft vehicles, and traffic monitoring in smart cities. Cheng-Hung Lin et al. [1] has proposed an approach for efficient hierarchical license plate recognition system. In this approach they used YOLOv2 model , SVM, LPRCNN model in order to capture and detect the character in the license plate but this approach has an flaw where it doesn't detect the theft. Gibrael-Elamin [2] proposed an system for localizing vehicle plate number inside plane images in this technique they use multi-window-size binarization and semi-hybrid genetic algorithm using the technique Substitution operator but it will be depends on the shape and color. G. L. Corneto [3] have proposed an approach for a new method for automatic vehicle license plate detection using the HAAR Cascade classifier technique but this approach is only identifies the number plate and do nothing to it. Safaa S. Omran [4] has proposed an approach in application software for the recognition of car license plate is designed by using the technique Optical character recognition (OCR) but in this approach it has Irrelevant features extraction. Neha Rana [5] proposed an approach called Localization Techniques in ANPR Systems by using Signature Analysis technique but it has flaw which is Improper illumination and blurring. Hossein Ziaei Nafchi [6] has proposed an approach for CorrC2G: Color to Gray Conversion by Correlation using the Decolorization method in order to detect the number plate but it doesn't work for every image. Rajshekhar Mukherjee [7] proposed a robust algorithm for morphological, spatial image-filtering, and character feature extraction and mapping employed in order to detect the vehicle number plate recognition using fuzzy logic and template matching technique. Hui Li [8] has proposed towards end-to-end car license plates detection and recognition with deep neural networks using the technique called Linear Discriminant Analysis (LDA) but it need more processing time. Ihsan Ullah [9] have proposed an approach of locating Korean vehicle license plate based on Mathematical Morphology and Geometrical Features in this approach they use Mathematical morphology technique this approach is affected from low location rate. Animesh Chandra Roy [10] has proposed License Plate Detection and Character Recognition System for Commercial Vehicles based on Morphological Approach and Template Matching using Boundary based contour algorithm but this approach need more training data.

This paper is organized as follows: The algorithm used to implement the LPR system is described in section III and Experimental results are described in section VI. Finally, Conclusions are summarized in Section V.

III. THEFT DETECTION IN THE TOLL BOOTH USING VEHICLE NUMBER PLATE

Each vehicle will be provided by license plate number containing a unique ID. The license plate number is captured using the camera placed in the toll booth. Then, the vehicle object is converted as a black and white image using the binarization algorithm and the condition random field(CRF). The algorithm detects the number in the vehicle which should be already trained by using the convolution neural network(CNN). For extracting the text from the detected number plate optimal character recognition(OCR) algorithm is used. The text which is extracted from the number plate act as a primary key in the database and started to see a match for data in stored database. The user will get an one-time password(OTP) in his registered mobile number which is stored in database for a particular number plate. If the given OTP is not matched with the admin side then it is a theft vehicle and the alert message will be sent to the concerned police officer. If the OTP is matched then the user can pay the toll fee either online or offline mode. In this theft detection approach in toll booth using vehicle number plate offers many advantages: 1. It save time, 2. It provides real-time alert system, 3. It maintains the records in the database for further references.

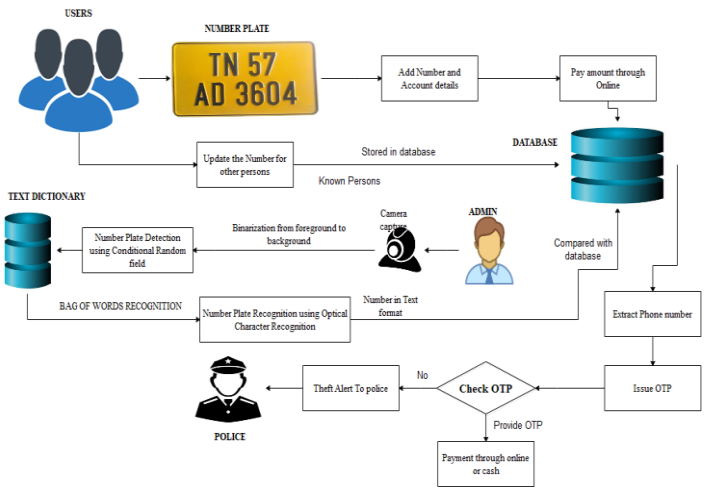

Fig 1.Theft detection in toll booth using vehicle number plate

a) Binarization

In this Fixed Thresholding binarization method, the fixed threshold value is used to assign 0's and 1's for all pixel positions in a given image. The basic method of fixed binarization is described below.

$$g(x,y) = \begin{cases} 1 \ if \ f(x,y) >= T \\ 0 \ otherwise \end{cases}$$

Fig 2. Fixed binarization

Where T shows the global threshold value. The threshold is a way of exacting the useful information from the given image and it will be encoded into pixels by reducing the background noise. It can be archived by a feedback loop to optimize the threshold value before converting the black and white image to binary. Here the ultimate objective is to separate the image into two parts foreground and background. Initially, we select the threshold value and split the image into two different parts. For background, the pixel value should be less than or equal to the threshold and for foreground the pixel value should be greater than the threshold value. After that, the mean average is calculated for two new images and the threshold is calculated by finding the average of two mean values. If the previous threshold value and the new threshold value are below a specific limit then the threshold process is completed. Otherwise apply a new threshold to the image and keep trying the same by repeating the entire process.

b) Conditional Random Field

A CRF is an undirected probabilistic graphical model, it represents the relationship among different variables. The structure of the CRF model is used to determine the unobserved one to observed one. CRF assigns a word tree by using the probability of occurrence of each character. The correct sequence of characters with high probability path is selected in forming the word. By using the conditional random field, it helps us to detect the features of an image using the pixels and filtering concept. In our case, the conditional random field is used to detect the number plate and text strokes from the number plate. It stores the details in text dictionary where it passes the bag of the words for fetching the users details to identify the theft in the toll booth.

c) Optimal Character Recognition

In the OCR technique, it extracts the text from the given input image before that the image acquisition should be done then the noise should be removed from the given input image by preprocessing after that image segmentation is done for grouping the characters into meaning full chunks and the text should be trained by using CNN. Initially, it differentiates the word contours associated with the input image then it will differentiate the letter contours associated with the word contours and the letter contours are detected using the feature detection concepts that means if two horizontal lines and one vertical line connected then it detects the character as A. After that, it will preprocess the letter image according to the trained OCR input. Consolidating ConvNet predictions of characters to text. By using the OCR technique the accuracy will be higher it has 95% accuracy and a 5% error rate in most cases.

d)Modules and Its Description

Some of the important modules which are used inour system namely Framework Construction, Image Acquisition, Text Detection, and Recognition, Membership Access, Payment With Alert.

i) Framework Construction

By using the electronic toll collection system our goal is to reduce the delay by using the smart way for collecting the toll which is proposed in our system and this kind of technology should be introduced and improved so that it will save time. This is a module where the user can register their name, phone number, and other details. Where the number plate is captured and the details of the number plate will be stored in the database and from the admin end all the user details can be maintained in the single database.

ii) Image Acquisition

In this module from the admin end by using the digital camera they will capture the image. Binarization is the most important pre-processing step in image processing. Then the binarization technique is implemented to detect and separate the foreground and background from the detected image. Where every pixel has its threshold value if the pixel is white in the image then the threshold value will be 0 else the threshold value will be 255. By using threshold binarization the accuracy of the image will be higher.

iii) Text Detection and Recognition

In this module, after processing of Binarization technique, the number detection approach would be obtained based on text strokes. A strokes value is the process of defining the values as minimum and maximum in the order of obtaining in the number plate based on styles and fonts. The strokes value removes other identified objects which have very small or very large objects, it will be removed and in the range of outside the threshold. The objects are successfully passed from the predefined threshold to the training process. After the text detection process, the text strokes in the number plate detected were recognized by the Conditional Random Field Algorithm.

Using the Conditional Random Field technique, the detected texts are assigned as bounding box and then the bounding box text will be recognized by using Optical Character Recognition. This algorithm which is Optical Character Recognition was recognized the detected text. Optical Character Recognition is a software that was used to

converts images and printed text into a digitized form of the process using capturing the image with the help of a webcam. The process can be manipulated by machine only. OCR is one of the complex problems because of the different languages, variety of fonts and different styles, and the complex rules of languages.

iv) Membership Access

In this module, After the Optical Character Recognition technique, the detected text will be checked from the databases. The databases stored some user data's which is name, phone number, address, and other details during the registration process of buying a vehicle. The user data are stored in the databases which collect user information for identifying the vehicle which is the user's or not. This process may be held by the admin side. The process of admin was checking the output of number plate detection using the Optical Character Recognition technique and the database's information which was user data.

Users can also update new numbers for future verification due to if the vehicle was driven by the user's neighbor means how he manages to admin. So, it was very useful to the user may update their neighbor number. The admin can store the details in the system which was who drives the vehicle and to license number plate, vehicle types, amount, date of arriving, and vehicle images with the help of a webcam. The admin can easily get the information day by day in the toll plaza in the system. The user can set the source and destination in the system only after checking tolls in the system to calculating the number of tolls and easily pay the amount online directly.

v) Payment With Alert System

In this module, After completing the verification process of user data using databases which were given by the user. If there is nothing problem with the verification process means, it sends the OTP to the user's mobile number. Using this OTP users can pay the amount simply either online or offline mode. At the same time, if the OTP can't be submitted within seconds from the user means, it automatically considers as a theft vehicle and it sends an alert immediately to the police number. An OTP is a secure one then a static password. So, it can't be hacked the OTP number which was more secure. The user can updates the new number in the login authentication due to the purpose of when the friends or neighbors can use the user vehicle. For this situation, the user may have an additional number to update in the system authentication. Due to this update, there is nothing problem to the user and the admin side also and easily identified by the admin so it can't take time to process and the queue may not be formed, the time will be saved.

IV. EXPERIMENTAL RESULT

Experiments have been performed to test the proposed system, the recognition of sample images and to measure the accuracy of the proposed system. It is designed using python using the library openCV for recognition of license plate. The measurement of accuracy is given in Table I.

TABLE I.
MEASUREMENT OF ACCURACY

Units of License Plate Recognition	Number of Accuracy	Percentage of Accuracy
Extraction of plate region	35/40	87.5%
Extraction of character from plate region	32/35	95%

For extracting the plate region from the 40 images which are stored in the database, only the 35 images extract the number plate correctly from the test images. The reason for not extract the number plate for the remaining 5 images is due to the unclear image will wipe out some important information so it causes the incorrect crop of the license plate has occurred.

For extracting the character from the number plate region on the 35 images which are stored in the database, among 3 images are correctly extracted the license plate but the text extraction from the license plate is not proper because it detects some noise or extra object in the number plate.

The results of the number plate recognition in the different scenarios for some of the cars are given in Table II.

TABLE II.
RESULT OF NUMBER PLATE RECOGNITION

License Plate variation	Original image	License Plate Image	Result with proposed method	Accuracy with proposed method
1)Image with multiple license plate				95%
2) Image with blur				96%
3)Image taken at night				97.18%
4)Image with rotation				96.89%

V. CONCLUSION

In this paper, we have proposed an efficient license plate recognition in the toll booth for identifying theft of vehicles. This detection technique uses OTP verification

from the user end to the admin end. The fixed threshold binarization can identify vehicle object in the image to avoid multiple detections or different objects in the given input image. Conditional Random Field is used to detect the number plate from the given vehicle object with high accuracy. In addition to that, for text extraction from the number plate Optimal Character Recognition is used which gives high accuracy in text detection from the given image. Here, the vehicle number is matched with database repository and OTP is sent to the user end and admin end. OTP verified with the admin end and user is allowed to pay toll fee either in online/offline mode provided the OTP is authenticated else an alert message is sent to the police officer as the vehicle is stolen. Experimental results shows the superiority of the proposed approach in terms of accuracy and performance.

REFERENCES

[1] Lin, Cheng-Hung, Yong-Sin Lin, and Wei-Chen Liu. "An efficient license plate recognition system using convolution neural networks." In *2018 IEEE International Conference on Applied System Invention (ICASI)*, pp. 224-227. IEEE, 2018.

[2] Abo-Samra, Gibrael-Elamin. "Application independent localisation of vehicle plate number using multi-window-size binarisation and semi-hybrid genetic algorithm." *The Journal of Engineering* 2018, no. 2 (2018): 104-116.

[3] Corneto, Guilherme Lofrano, Francisco Assis da Silva, Danillo Roberto Pereira, Leandro Luis de Almeida, Almir Olivete Artero, Joao Paulo Papa, Victor Hugo Costa de Albuquerque, and Helton Molina Sapia. "A new method for automatic vehicle license plate detection." *IEEE Latin America Transactions* 15, no. 1 (2017): 75-80.

[4] Omran, Safaa S., and Jumana A. Jarallah. "Iraqi car license plate recognition using OCR." In *2017 annual conference on new trends in information & communications technology applications (NTICT)*, pp. 298-303. IEEE, 2017.

[5] Rana, Neha, and Pawan Kumar Dahiya. "Localization techniques in ANPR systems: A-state-of-art." *International Journal of Advanced Research in Computer Science and Software Engineering* 7, no. 5 (2017).

[6] Nafchi, Hossein Ziaei, Atena Shahkolaei, Rachid Hedjam, and Mohamed Cheriet. "CorrC2G: Color to gray conversion by correlation." *IEEE Signal Processing Letters* 24, no. 11 (2017): 1651-1655.

[7] Mukherjee, Rajshekhar, Amit Pundir, Dharmendra Mahato, Gaurav Bhandari, and Geetika Jain Saxena. "A robust algorithm for morphological, spatial image-filtering and character feature extraction and mapping employed for vehicle number plate recognition." In *2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, pp. 864-869. IEEE, 2017.

[8] Li, Hui, Peng Wang, and Chunhua Shen. "Toward end-to-end car license plate detection and recognition with deep neural networks." *IEEE Transactions on Intelligent Transportation Systems* 20, no. 3 (2018): 1126-1136.

[9] Ullah, Ihsan, and Hyo Jong Lee. "An approach of locating Korean vehicle license plate based on mathematical morphology and geometrical features." In *2016 International Conference on Computational Science and Computational Intelligence (CSCI)*, pp. 836-840. IEEE, 2016.

[10] Roy, Animesh Chandra, Muhammad Kamal Hossen, and Debashis Nag. "License plate detection and character recognition system for commercial vehicles based on morphological approach and template matching." In *2016 3rd International Conference on Electrical Engineering and Information Communication Technology (ICEEICT)*, pp. 1-6. IEEE, 2016..