International Conference on Recent Trends in Data Science and its Applications
DOI: rp-9788770040723.153

Residential VehicleSecurity System Using YOLOv5 Framework

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***Abstract*—Security automation is essential today because it has become one of the main concerns for any organization. Many of the solutions that are currently available are still unreliable in real-world settings because they frequently depend on numerous constraints. In the project that follows, we will learn how to identify license plates using the Object localization and OCR. For this project, we'll use the YOLOv5 framework for license plate localization, then identify the license plate text using EasyOCR. This study will also show how a cutting-edge YOLO object detection-based ALPR system can be reliable and successful. The results show that a trained aneural network working with a high accuracy of about 90-95 percent can recognize license plates in low-resolution pictures.**

This project will present a robust and efficient ALPR system based on the state-of-the-art YOLO object detection. The results have shown that the trained neural network is able to perform with high accuracy of nearly 90-95 percent in recognizing license plates in low resolution images using this system.

Keywords*—Deep Learning, YOLO, Object Detection & Localization, OCR, Easy OCR, License Plate Recognition, ANPR, Residential vehicle security

I. Introduction

These days there is an increasing need for security in residential complexes, be it big or small. We believe using our application, it is possible to provide maximum security to such buildings. There are often hindrances while finding out whether a person entering the building via any vehicle is a person belonging to the community or not. This can be done via manual checking but it is a very tedious job for the security personnel. Using the app, we have developed, all they have to do is take a photo of the incoming vehicle, that is all.

The code we've written recognizes the license plate and uses OCR to extract the text from it. After this, it matches the said license plate with the ones in the database, thereby finding whether the vehicle belongs to the building or not. In this project, we aim to provide the following features - (a) Identifying vehicles that belong to the premises, Creating and storing the vehicle/owner information in the database, such that their parking lot for each vehicle is assigned and mentioned in the database. From this we can fetch the data we need to verify in future.

So, whenever any vehicle enters the residency, the security guards will simply click their picture from the application, and our deep learning model will extract the text of the license plate and cross verify with the database if it is present or not. (b) Availability of parking spaces: Another big problem which residential management faces is parking on wrong slots/ or some outsider's vehicle is parked at a pre-allocated slot of some resident. Keeping a track of that and verifying those things again is a big problem. In case a visitor enters with their vehicle they don't know where to park so they at times park at someone else's parking area, or on roads, or at places which might create problems in the future. This app will temporarily allocate free parking spaces, and its location, once authorized, so that they can park freely and safely without any disputes. (c) Allotment of parking space for newly registered vehicles: When an existing resident gets a new vehicle, or a new resident arrives, once they are authorized, this app will give them an option to select and pick any slot available and permanently allocate that slot to them. (d) Reducing the labor work of security personnel: This Application is designed so that it will avoid a lot of paperwork and verification work done by security personnel everyday 24/7. This app is simple to use for anyone to use with/without having a technical background. And it's one more new step towards digitization.

II. Literature Survey

For solving real world problems likevehicle parking to traffic control, a realtime ANPR model has established itself as a vital instrument for access-control &improved management of traffic. In previous model, the vehicle license plate area was located using a number of localization techniques, including contouring, edge-detection,and others. These ANPR model may function under limitations like darkness or light, angle view of plate, and poor resolution stated in [3] by using simple image processing algorithms. Previous research employed image preprocessing techniques including edge detection and contouring for the detection of number plates, which included the use of serval localization algorithms.

Additionally, [4] discusses both online and offline versions of the ANPR system. In contrast to offline ANPR models, which take pics for additional processing with the help of OpenCV, as it has numerous predefined algorithms, which aresuitable for realtime application, online ANPR systems interpret incoming video frames to enable real-time tracking.

Using a Raspberry-Pi, Fakhar et al. suggested a cheap ANPR system in 2018 [5], where the model makes use of a real-time picture taken from a camera. The characters on the plate are recognized once the picture has been denoised, filtered, and segmented. All complex calculations are handled by the Raspberry-Pi, and there is a discernible 3-second delay before the outcome. The database also stores

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the outcome label. [6] presents the ANPR technology for smart check-in and check-out, which shortens wait times and records vehicle entrance and leave. In order for ANPR systems to instantaneously identify the license plate text using image-computing and record the adding vehicle and security info in the database through a web-app, images from CCTV cameras must be gathered. The suggested method would shorten check-in times and ease parking and traffic congestion.

The ANPR model in POLIMAS, that confirms that only authenticated cars are allowed to access the designated site, was proposed by Nui Din and Virakwanin [7]. There are four alternative ways to install a webcam: back, front,rear, and top. The acquired picture is made gray-scale, and then the histogram equalization method is used to modify the contrast and intensity. A combination of Sobel-edge and Laplacian-edge detectors is used in the bounding box technique to identify and crop character region, yielding 95.83% confidence of localization of license plates. In OCR, each character is compared using eigenvectors and correlation. Character recognition accuracy using the suggested method was 87.41%. The results are gathered in a string format& contrasted with the reserved records in the DB.

Liu &Chou [8] introduced a real-time truck license number verification system that decreases the manual efforts and labor, additionally time-spent in verifyinglicense plates since identification remained difficult owing to the diverse forms of plates in different locations. Their approach successfully lowers the likelihood of crime while enhancing the efficiency, automation, and transparency of front-line workers. Using Yolo& CNN based Deep Learning frameworks, this model achieved a single-character detection rate of 97.59%, and overall accuracy rate was 93.73%, and at inference-time of 0.32 sec/image.

In [9], Chen and Hu presented an ITS that emphasized video dedicated vehicle recognition & classification methods that rely on static & motion each information to get better results. Under environmental variables, such as various illuminations, the suggested approach localizes the vehicle license plate region &detectscharacters from license plate with a 95% confidence score.

In [10], a car plate identification system depending on OCR &WSN (wireless sensors network) was discussed. The suggested model takes pictures of parking spots using the Smart Parking Service (SPANS) framework and detects in-motion as well as parked automobilelicense plates. Real-time photos are also used to evaluate the system's performance. R. N. Babu et al. in [11] employed cutting-edge DL approaches for plate identification. 6500 Indian license plates made up their picture dataset, which was split into training and testing sets in a ratio of 90:10. Three separate cameras, each with a different data rate and focal length, were used to take the pictures. For character recognition, a 37-class CNN model was trained. The model employs 126 filters, and YOLOv3 is utilized to decode the license plates of moving vehicles. For license plate character recognition, they attained a 91% accuracy rate.

In addition, using a KNN-based approach, character identification is accomplished in [12] with a 98% accuracy rate. The pictures were captured with a webcam that has a 640 x 480-pixel resolution. The procedure made use of thresholding, grayscaling, edge-detection, morphological and inversion techniques.

Different segmentation techniques were used by Ariff et al. in [13] for the cleanup and evaluation of the noisy number plate photos. 100 Malaysian number plates with high resolution of 1932x2576p were evaluated utilizing threshold techniques like NiblackandSavoula to get rid of unwanted pixels. The average accuracy of Savoula segmentation inthis situation is 83%. Character classification is done using the template matching approach.

A precise VNPT recognition method based on an OCR engine is suggested in [14]. The input license plate pic is converted to grayscale, subjected to global image-thresholding by utilizing Otsu technique, and had its noise removed. OCR is used to perform character recognition on the processed picture. The outcome is subsequently placed in a text-file as a string. The overall precision of the system ranges from 90% to 100%.

ALPRNET, a neural-network called and two full-convolutional onestage object predictors for concurrently identifying & categorizing characters and license numbers, were presented by the author in [15]. [16] introduces a global license plate identification system that uses Tiny YOLOv3, YOLOv3-SPP (spatial pyramid pooling), and unified character sequence detection to identify the layout of 17 distinct nations.

III.PROPOSED SYSTEM

From the past research addressing ANPR, we discovered that two alternative approaches were often employed for character detection in the ANPR models. The basic technique is EasyOCR & the other technique is connected to Deep Learning. Also, we employed these two techniques for rapid deployment of our suggested ANPR system, which has a unique system specialised to Residential vehicle license authentication was introduced. In this study, we have refined our previously suggested pipeline for license plates & investigated its use in autonomous vehicle authentication.

About traditional ANPR model, it’s not very efficient & precise in finding license plate's position and recognition technique due to diverse real-world scenarios like,lighting as well as the quality of clicked pictureduring the acquisition phase. Traditional ANPR pipeline involves these stages: picture capture, plate identification, pre-processing of retrieved plate, and license plate identification. The suggested realtime ANPR model takes the multiple frames from the surveillance footage and, using YOLO object identification framework, detects the front or rear image of automobile in order to establish the check-in or check-out condition for the authenticationmodel. Following that, the license plate can be tracked by using the YOLO framework.

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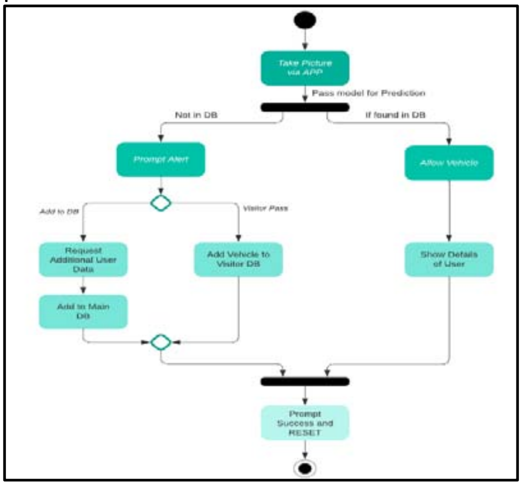

Fig. 1. Flow diagram

In the end, license plate characters are detected by efficient OCRmodelslike CNNbased frameworks or EasyOCR. Fig. 1 shows theflow diagram of our proposed Licence plate recognition model. This project has 4 major modules, the Flutter Application, Flask Integration, Database, Train YOLOv5 model.

A. Training YOLOv5 Model

We are training the YOLOv5 framework for license plate localization since YOLOv5's object detection model is relatively fast and gives precise results in a real time application. YOLO (You Only Look Once) is a real-time object detection algorithm that processes an image in a single pass, identifying objects and their bounding boxes. It achieves high accuracy and fast performance by using a convolutional neural network to simultaneously predict object classes and locations. It is trained on vehicle's license plate images in both front and rear view. We provide only one classifier 'license plate' as per requirements. We took the dataset from Kaggle with 433 images with bounding box annotations of the car license plates within the image.

In the pre-processing step we resized and converted every image into a list of coordinates of size 224x224 (which is standard size for pretrained transfer learning models). Then we split the data into train & test with the ratio of 75:25. Then we finally train the model with the YOLOv5 model with the YOLOv5s weights (which is ideal for smaller datasets). As a result yolo will return the images with the bounding boxes around the localized license plate region with a number as the confidence score (as shown in Fig 2). The weights in the "best.pt" file represent the optimized values for the model's parameters that allow it to perform well on the task it was trained for. We saved the 'best.pt' trained weight from the model for the deployment code.

Fig. 2. Output of YOLOv5 Train model

B. FireBase (Residential Vehicle Database)

A small database is created in Firebase. Firebase is a mobile and web application development platform that provides a suite of backend services to help developers build apps faster. We are using its real-time database for the vehicle database of the residencies, so that we can easily add, fetch & search the records in the database in real time. The database is stored as a nosql database in the format of collections with the attributes - owner_name, license_no, flat_no, contact_no.

C. Flutter Application

Flutter app will be used by the end users, to click pictures from the app and verify the cars.The workflow of this task will process as the user clicks picture, it will be sent to Flask UI through an API and the authenticity and details of the car and car owner(if legitimate) will be returned and displayed,

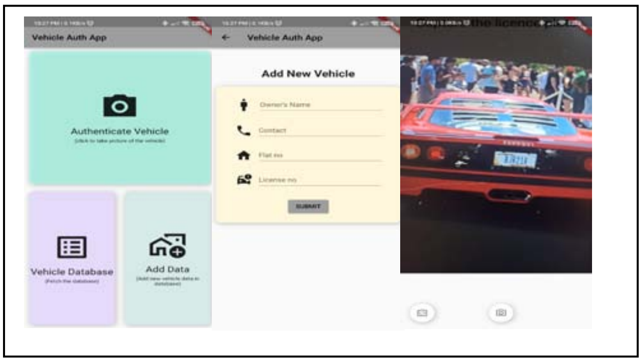

Fig. 3. UI of Flutter APP

After which the user can take further actions accordingly (add to database or temporarily allocation of available spaces etc.). Apart from this the UI has some additional features like, adding new Vehicle data to the Database & viewing the residential vehicle database on the app itself.Figure 3 depicts the User Interface of flutter app.

D. Flask App Integrity (Deployment code)

In this module we have hosted a Flask web-app so that it can interact with Flutter app, & Firebase (that has Residential vehicle database). Also this app can run the deployment code when requested.

The deployment code is responsible for localizing the license plate & extracting the license plate number, from the given user requested vehicle image. This deployment code uses the YOLOv5 framework for license plate localization using our pre-trained weights from the previously trained model (saved in 'best.pt' file). This concept of using pre-trained weights/model is called Transfer learning. After getting localized license plate coordinates, we crop that region and pass it to the OCR(Optical Character Recognition) model for text extraction. Precisely we are using EasyOCR, which is a Python package that provides an easy-to-use interface for optical character recognition (OCR) of text in images and PDF files. It can recognize text in over 70 languages and supports multiple OCR engines for improved accuracy. In Fig 4, the flow of deep learning model is explained.

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The extracted text is returned to the flask app, which is then searched through the database in Firebase by using the queries and if found we fetch the owner's details else we get '-1' response, which we revert back to the Flutter app.

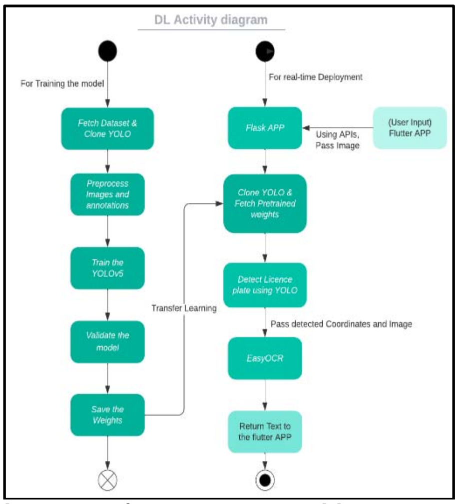

Fig. 4. Flow Diagram for Deep-Learning Model

III. EXPERIMENT ANALYSIS

After training with a total of 433 images of license plates, we used 300 epochs & 16 batch size. We can see the below mentioned plots (Fig 5) that there is a definite drop in the box_loss (the loss function that penalizes the model for incorrect predictions of the bounding box coordinates) and obj_loss (the loss function that penalizes the model for object detection errors, such as false positives and false negatives) after 200 epochs. For the best.pt weight with most optimal performance, the precision value was 0.97, recall was 0.99 & mAP (mean Average Precision) was 0.99.

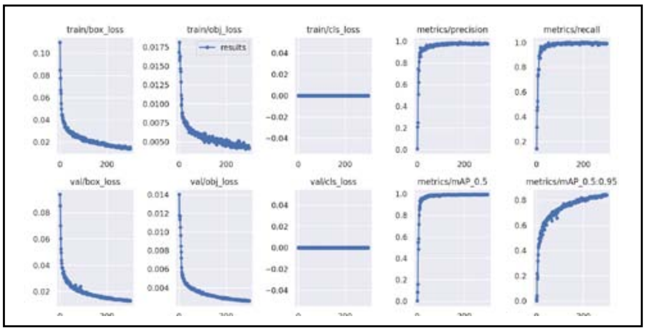

Fig. 5. Loss analysis

Figure 6 shows the F1 score of the model. By these values calculating the F1 score, using the standard formula we get 0.98 for the YOLO license plate localization.

Fig. 6. (a) F1 Score vs Confidence plot for YOLOv5 model; (b) Output of Deployment code after EasyOCR

IV. CONCLUSION

This project has presented us with a robust & an efficient Residential vehicle authentication system based on YOLOv5 object detection. In this model, we have used the concept of transfer learning, to integrate two models to create a deep-learningbased pipeline that is trained&validated for residential vehicle authentication apps. The results have shown that the trained neural-network is able to perform with high-accuracy of around 95-98% in localizing license plates in low-resolution picswith the help of this system. We can improve the model's performance even more by training it on Indian vehicle license plate images and videos. This system has potential to replace the trivial manual vehicle verifying process with its automated and fast approach. Furthermore, we can add more useful features to this system to ease the management task, such as allocating unallocated parking spaces to the visitor's vehicles, temporarily and integrating this model to a live streaming device (through CCTVs for example) to make this process completely automated instead of relying for manual clicking of pictures.

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