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YOLO-based Automatic Number Plate Recognition System

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Abstract: Populated cities such as Bangalore has become a challenge over the years to manage the traffic. Traffic management in such cities plays a significant role in providing a safe transportation system to the citizens. One such concept that could be considered for controlling the traffic is through the management of traffic violations. An effective traffic management system is crucial to increase drivers' awareness of responsibility and behavior. However there are many issues associated with the traditional traffic fine management system which often involves paperwork, delay in processing and lack of transparency.
In the digital world there is a requirement of an efficient system to manage and reach the immediate goals of development and sustainability. In the digital world there is a requirement of an efficient system to manage and reach the immediate goals of development and sustainability. However there exists applications to handle the traffic across urban cities .but trough this platform we are trying to create a better application that could be accessible both in rural and urban areas. Fine Scan Pro is envisioned as a mobile application designed to provide a comprehensive platform for citizens, traffic police officers, and administrators to efficiently report, manage, and adjudicate traffic violations.
It is an intelligent traffic violation reporting application that represents a proactive. response to the existing challenges by seamlessly integrating modern technologies into the traditional traffic management framework. and responsive approach to traffic management[1]. The project was created in response to the increasing demand for a technology-driven, real-time system that would guarantee accuracy and equity in the imposition of fines while also speeding up the reporting and processing of traffic infractions.
Keywords: Number plate detection, Number plate extraction Number plate segment extraction,YOLOv8.

INTRODUCTION

Majority of the road accidents[2] or rules violation such as speeding, ignoring the signals, ignoring the safety equipment's in the vehicles such as seatbelts and helmets also improper overtaking of vehicles on road occur due to the distraction, lack of concentration or awareness. In rural areas these situations may arise mainly due tothe lack of awareness of consequences that need to be faced on the later part of violating the traffic rules. The road safety and drivers behaviour while driving solely depends on the fine management system as the only wayto carve human behaviour is by allotting fines immediately when the rules are violated. Our application Fine scanpro mainly focuses on using an object detection module YOLOv8.

YOLOv8 is a framework[3] that is designed to detect the objects within the images or video frames. Yolo has awide range of application in autonomous vehicles and image recognition. It is used to go beyond the conventional system of image detection by splitting the image into several grids and processing the entire gridin a single pass. This method has performs its best in real time applications where high accuracy and processingspeed can be achieved. FineScan Pro is not just a reporting tool but also a comprehensive system that encourages accountability and transparency in traffic management. The application is further enhanced by the addition of real-time location tracking, payment gateway integration, and a fine appeals system. making it a holistic solutionfor traffic violation management. As the world moves towards smart solutions for everyday challenges, Fine Scan Pro stands as a testament to the power of technology in enhancing public services. This project explores the intersection of mobile application development, machine learning, and cloud hosting to create a robust, user-friendly, and efficient system for managing and mitigating traffic violations.

The ML algorithm used throughout the project is YOLOv8(You look only once version 8) which is an object detection algorithm which belongs to the family of single-stage object detection algorithm. It processes the image on a single pass through neural network. This algorithm uses convolutional neural network as its backbone to extract features from input images. Using these concepts an automatic number 8 plate recognition system is developed.

LITERATURE SURVEY

The system proposed and implemented by Al-abassi *et al.*[4] involved RFID tags, readers, a mobile Android app, and a main processing unit to autonomously register fines and aid traffic officers. The

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cost-effective approach utilizes low-cost equipment, such as Arduino Uno microcontrollers, for local processing units, highlighting the practicality of RFID in traffic management. This system not only monitors violations but also provides real-time information to traffic officers. The mobile application, designed using MIT App Inventor, allows officers to perform various tasks, including checking violations, adding balances, and monitoring vehicles periodically. The system aims to enhance traffic management in Iraq by combining RFID technologywith IoT[5].In the later part a mobile application was proposed to assist traffic police officers in their daily tasks, specifically focusing on 4 developing a prepaid traffic violation method for Iraq. The app connects to police officers' smartphones, controlling the registration and monitoring of drivers, fine charging, and SMS notifications for violations. The project was tested on a prototype in An-Najaf city, showcasing the practical implementation of the proposed mobile application for efficient traffic management.

In [6], a system was proposed to track fast-moving vehicles using existing roadside surveillance cameras. The traditional approach of analysing Realtime CCTV footage is complex. To address this, the system utilises a powerful deep learning model called YOLOv8 for object detection. In the system the video footage was brokeninto individual images one per frame where YOLO was used to analyse each image and to identify the car. Oncethe car was identified a similar methodology was used to detect the licence plate in the same image.The systemuses powerful technology to read the letters and numbers on the licence plate.Najeem Owamoyo, A. Alaba Fadele and Abimbola Abudu developed Automatic Number 6 Plate recognition for the Nigerian vehicles where number plate extraction was done using Sobel edge 2 filter, morphological operations and connected component analysis, vertical projection analysis is used for character segmentation [7].

In[8], a convolutional neural network-based system for identifying and detecting car number plates was created. There are two components to this system: the detecting system and the number plate recognition system. A digital camera was used in the detecting system to take a picture of the car, which was subsequently divided into several frames. The image was changed from low resolution to high quality using a resolution procedure after the number plate 1 region was extracted. In order to rebuild the quality of the input image, the CNN convolution layer employed this super resolution technique. However, the bounding box technique was used to segment each character on the license plate. CNN was used to extract and classify features in the secondsection, which is the recognition section.

A method based on the Sobel edge detection method 1 and morphological operation—which is straightforwardbut effective—was employed in [9]. In this procedure, the bounding box method was utilized to segment all ofthe letters and numbers used in the number plate. Following the division of the digits and characters on the number plate, the 2 numbers and characters were recognized using a template matching technique.

PROPOSED APPROACH

Problem Statement

The goal of this project is to develop an effective number plate recognition system that will allow traffic flow optimization and vehicle movement tracking. Moreover, restricted zones and speed limits on highways can be enforced using ANPR. Additionally, to detect illegal cars parked in parking lots by creating a technique that maybe applied in communities where using cameras is impractical.

DATASET USED

LabelImg is a free, open-source graphical image annotation tool specifically designed to label objects withinimages.

The breakdown of what LabelImg can do:

- Draw Bounding Boxes
- Assign Labels
- Save Annotations

We have labelled 750 images(.jpg) using LabelImg in Pascal voc format. The datatset consists of 750 uniquetwo wheeler images(Indian number plate).

The dataset used is automatic number plate recognition from Kaggle[10]. It contains a total of 453 files. Eachfile is an image in the widely used JPEG format (.jpg).What makes this dataset valuable is the additional information stored alongside the images. These annotations provide crucial details about the location of car licence plates within each image. This dataset utilises the PASCAL VOC (Visual Object Classes) format for annotations. PASCAL VOC is a standardised format commonly used in object detection tasks. It allows researchers and developers to easily store and share information about objects present in images. In PASCALVOC format, for each image there is a xml annotation file containing image details such as bounding box details, classes, rotation and other data.

This dataset provides a collection of real-world images containing car licence plates. The annotations stored alongside each image, in the PASCAL VOC format, conveys exactly where those licence plates are located within the image. This makes the dataset ideal for training and evaluating computer vision algorithms specifically designed for car licence plate detection

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PROPOSED METHODOLOGY

Fine Scan Pro, an innovative mobile application, addresses this challenge by leveraging advanced technologies to streamline the process of reporting and managing traffic violations. Developed using React Native for the frontend, Node.js for the backend, and hosted on AWS, Fine Scan Pro provides a multi-user interface catering to citizens, traffic police officers, and administrators.

The application offers users an option to log in, view their driver's licence details, vehicle information, and outstanding fines. Users can conveniently pay fines directly through the app, enhancing the efficiency of the entire process. Simultaneously, traffic police officers have access to a specialised interface, enabling them to view licence and vehicle details, also upload images of violations. Behind the scenes, a robust backend systemutilises machine-learning models to identify vehicles through licence plate recognition, automatically updatingthe database with necessary fines.

The network architecture used for the detection of number plates in the project is YOLOv8(You only view once). This process involves training on the dataset which involves images containing vehicles with annotated bounding boxes around their number plates.

The administrative interface also empowers the administrators to manage driver's licences, vehicle records, and fine details. Additional features include the capability to modify fines, add new licences and vehicles, ensuring the system remains adaptable to changing regulatory requirements.

Our project's goal is to make it easier for citizens to report traffic offenses by offering an easy-to-use interfacethat makes it simple to submit facts and supporting documentation. The application uses machine learning models to automate license plate recognition and vehicle identification, providing traffic enforcement personnel with a quick and precise decision-making process. By enabling citizens to check their driver's license details, car information, and outstanding fines, Fine Scan Pro improves transparency. Accountability is encouraged by this transparency for both the general public and traffic management agencies.

The various stages used in this methodology are:

Number Plate Detection

This step involves training of YOLOv8 model to 3 identify the number plate from the image frame. This processinvolves collection of dataset of various number plate images and annotate the data on number plate by bounding boxes around each image and train 7 the model in order to recognize the number plates automaticallyon basis of the pattern obtained.

Optical Character Recognition (OCR)

After the stage of number plate detection by YOLOv8 the text must be extracted which is done by OCR engine. The OCR engine[11] processes the number plate detected and generates an output of the characters thatwere recognized.

Data Preprocessing

The preprocessing and augmentation steps applied to the licence plate dataset are Auto-Orient: Applied Resize: Stretch to 640x640 Augmentations

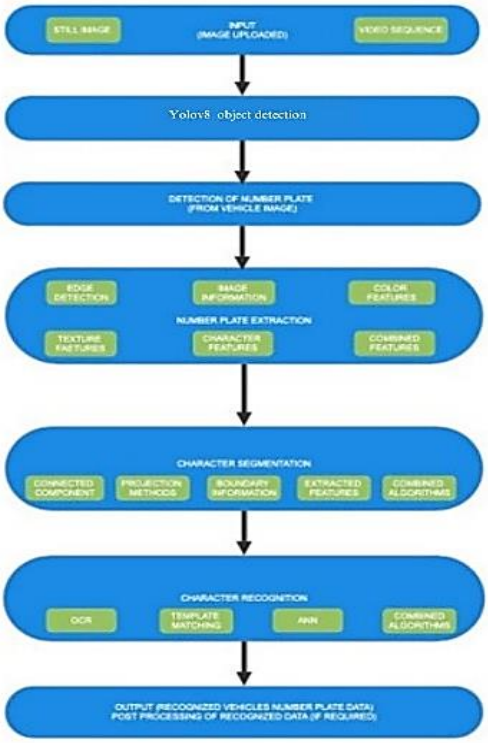

Figure 1. Dataflow Diagram

RESULTS

The results from the system developed is described in 6 this section. The performance metrics of a system can be measured by considering the factors such as f1 score, precision. Through the system factors such as F1 and precision[12] the F1 confidence curve obtained by the model is shown in fig2.The model is predicting the presence of a licence plate in an image. A high confidence score (close to 1) would indicate that the model is very certain there is a licence plate in the image, while a low confidence score (close to 0) would indicate that the model is unsure about the presence of a licence plate. It suggests that at a confidence level of 0.69, the modelachieves a perfect score (1.00) on all classes. This confidence threshold could be used to decide whether to accept a prediction as a licence plate or reject it. Also Precision curve obtained by the model in the fig 3 indicatesthat a high confidence score (close

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to 1) would indicate that the model is very certain the object in the image isa licence plate and the precision (y-axis) is also high, meaning the model's prediction is likely correct. As the confidence score decreases, the precision also goes down, which means the model is less certain the object in the image is a licence plate and its prediction is less likely to be correct. It suggests that at a confidence level of 0.74, the model achieves a perfect precision (1.00) on all classes. This confidence threshold could be used to decide whether to accept a prediction as a licence plate or reject it.

The precision recall curve [13] in the fig 5 indicates that

- The overall shape of the curve suggests a reasonable trade-off between precision and recall.
- The curve starts at a high point on the y-axis (perfect precision), indicating that the model can perfectlyidentify some objects at a very high threshold (very strict classification).
- As the threshold loosens (allowing more classifications as positive), the precision might decrease (more falsepositives), but the recall might increase (finding more true positives)

However, the fig 4 shows the confusion matrix of the model. The figure 6. is the histogram which shows the distribution of data. In this the data is represented as number of cells in each cluster. The x-axis of the graph represents the number of cells per cluster and the yaxis represents the number of clusters.

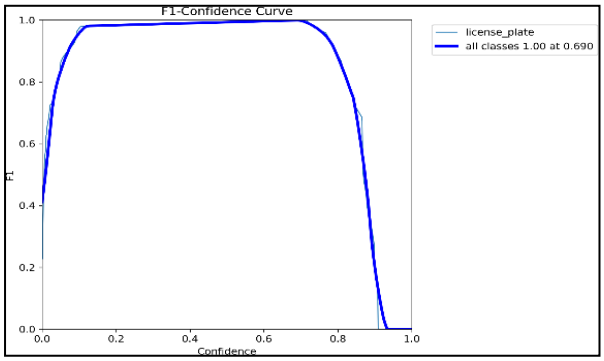

Figure 2. F1-Confidence Curve

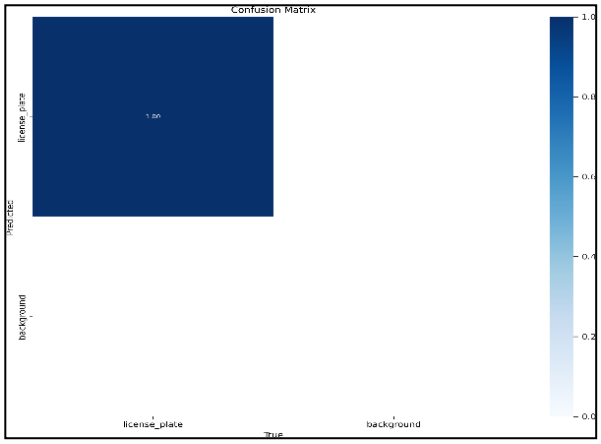

Figure 3. Confusion Matrix

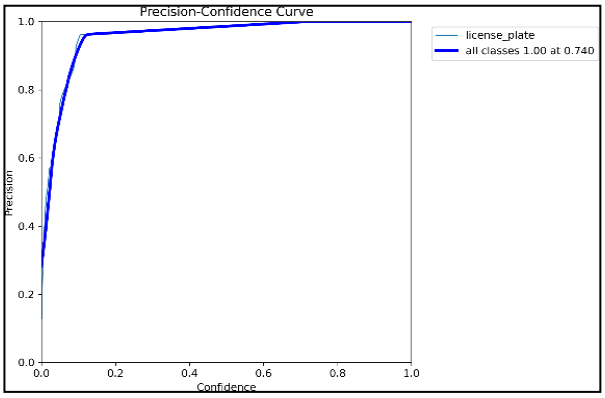

Figure 4. Precision-Confidence Curve

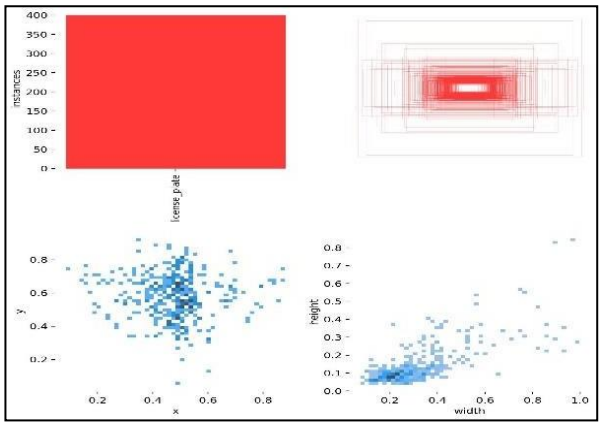

Figure 5. Precision Recall Curve

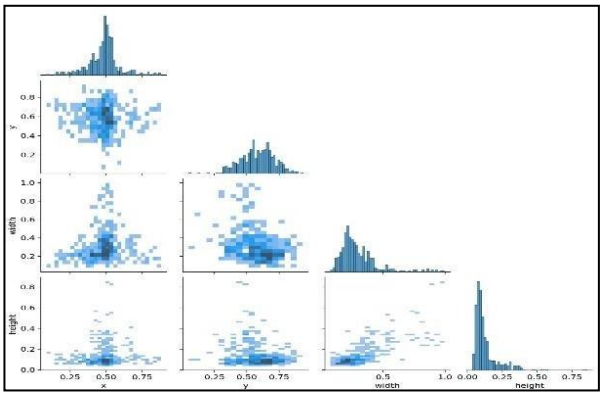

Figure 6. Results

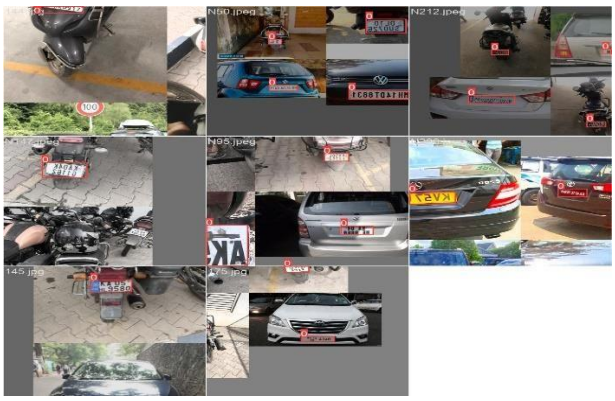

Figure 7. Train Batch

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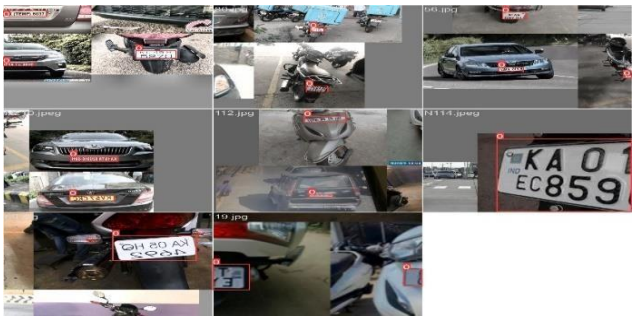

Figure 8. Val_Batch_Labels

CONCLUSION

The system has an accuracy around 85%. This rate in accuracy might be due to result of considering a comparatively smaller dataset. A smaller dataset would not always generate an efficient pattern for recognition and analysis. However the accuracy can be increased by considering a relatively larger dataset. Also The text labels in the confusion matrix indicate that the model has high confidence (0.8 to 0.9) in its identification ofsome licence plates in this batch. This is a positive sign. However it's important to evaluate the model's performance on a larger dataset to get a more accurate result.

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