ParkIt : A simple solution for Automatic Parking Registry

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***Abstract*—In today's busy environment, maintaining a congestion free and secure parking area is a difficult task to achieve. This project proposes a comprehensive solution to address this challenge by leveraging state-of-the-art artificial intelligence (AI) techniques. The AI-Powered Object Detection and OCR techniques aims to create a secure and trustworthy environment during parking, ensuring safe and reliable management of a parking space for academies or companies.**

***Index Terms*—detection,YOLOv8,OCR,deep learning and computer vision**

I. Introduction

The super fast growth of Artificial Intelligence (AI) has really impacted lots of different areas, like managing parking lots.One notable application is the automation of parking registration systems, which offers immense potential for streamlining operations and enhancing user experience. While handling parking registration for a limited number of vehicles might seem straightforward, managing large volumes of vehicle data poses significant challenges, consuming time and prone to errors. To address this challenge, the project aims to develop a robust automated parking registration system capable of efficiently processing vehicle information and instantly generating structured reports.the system alleviates the burden on parking administrators, enabling them to focus on more critical tasks. This innovative solution empowers parking management personnel to utilize their time more effectively, improving operational efficiency and accuracy in parking data processing across various facilities.

II. Literature Survey

The system description was based on the initial concept that was pitched before extensive research. The phases of this system concept may have existing solutions of various implications and importance which will be explored below.

Muhammad Gufran Khan et al. [1] proposed A Novel Deep Learning Based ANPR Pipeline for Vehicle Access Control in 2021. The paper provides ANPR system can significantly reduce the effort of service personnel, reduce the impact of human factors, and eliminate errors.The objective of this research is to develop a cost-effective, time-efficient smart ANPR system

Ravi Kiran Varma P et al. [2] proposed A Novel Method for Indian Vehicle Registration Number Plate Detection and Recognition using Image Processing Techniques in 2020. The major contributions of this work is to design an Indian vehicle number plate detection.Dealing with varying illuminated images,Dealing with bright and dark objects and Dealing with noisy images.

M.A. Jawale et al. [3] proposed Implementation of number plate detection system for vehicle registration using IOT and recognition using CNN in September 2023. They pro- posed ANPR, an effective method for automating watch keeping in traffic systems and parking fee structures, entails a proposed system with four integral steps: License Plate Extraction, Image Pre-processing, Character Segmentation, and Character Recognition. They use of CNN, MobileNet, Inception V3, ResNet50.

Muhammad Murtaza Khan et al. [7] proposed License Plate Recognition Methods Employing Neural Networks in 2023. They proposed focuses exclusively on neural network- based automatic license plate recognition methods, emphasizing convolutional, residual recurrent networks, particularly applied to tasks such as license plate detection and ex- traction. The utilization of AlexNet is highlighted within this context. Challenges are addressed, notably the variation in number plate standards across different countries. The above discussed literature provides the system with a possible solution for extract alphanumeric characters from the number plate.

Omer Aydin[6]proposed Classification of Documents Extracted from Images with Optical Character Recognition Methods in June 2021. It focuses on the fact that the printed documents have been digitalised by a scanner or digital camera

and these documents have been processed with two different OCR operations.

Sachin Shrivastava et al. [6] proposed CNN-based Automated Vehicle Registration Number Plate Recognition System in March 2021. It focuses on the different methods of VRNPR and emerging technologies that are used to get accurate results.

These research papers helped gain more perspective and understanding of how CNN can be applied to real-life scenarios and situations of the most importance.

III. Methodology

The proposed methodology for the automated parking registry using image processing involves several key steps. A YOLO model is trained to detect the number plates from the real time video feed from the parking area. An OCR system is used to extract the characters from the detected number plates. The OCR system is integrated with a database to store or cross-reference plate numbers with owner details. Concurrently, extensive user interfaces (UI) are developed for both students (vehicle owners) and security personnel, allowing vehicle registration, parking history tracking, entry/exit status notifications for students, and real-time entry log monitoring for security,

A. Dataset and Data Preparation

The data collection and preparation was one of the most time consuming and important tasks in this project. We obtained multiple dataset from the internet which included both Indian and international number plates of all kinds of vehicles. The dataset included Zsome erroneous images which were filtered out. The dataset was integrated and annotated using the online annotation tool Roboflow. We split the dataset into training, testing, and validation and created an YAML file for training a YOLO model.

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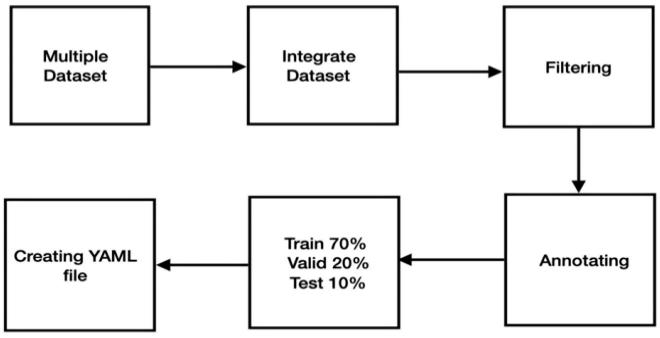

Fig. 1. Block Diagram Dataset Creation.

B. Model Architecture

The system begins by capturing real-time video using a camera positioned in the college parking area. This video stream is continuously fed into the system for processing. Each frame of the video is analyzed to detect vehicles entering or leaving the premises. Utilizing a custom YOLO model, the system identifies and tracks vehicle number plates in the video frames. Once a number plate is detected, the system crops and preprocesses the image, applying techniques like grayscale conversion and thresholding to enhance character recognition.

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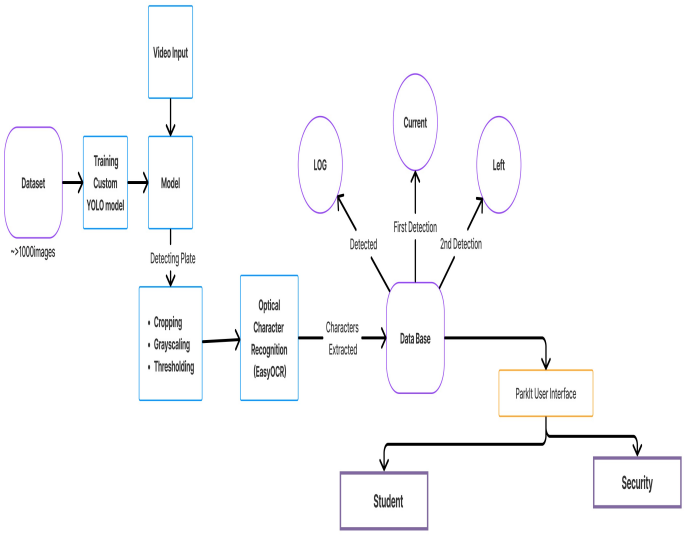

Fig. 2. Block Diagram of Proposed System.

The processed number plate image is then passed through an OCR (Optical Character Recognition) engine, such as EasyOCR, to extract the alphanumeric characters representing the plate number. Simultaneously, a line is drawn over the video frame to detect when the midpoint of the number plate aligns with the line, indicating the reading of the plate's characters. This event triggers timestamp recording, marking the vehicle's entry or exit time.

The extracted plate numbers and corresponding timestamps are stored in a real-time Firebase database called active plates for ongoing monitoring. Duplicate plate detections signify a vehicle leaving, prompting removal from active plates and recording in a Firestore database named left vehicles. The system's seamless integration of image processing, OCR, and database management ensures accurate and efficient parking log maintenance in real-time.

C. Model Training

In today's busy environment, maintaining a congestion free and secure parking area is a difficult task to achieve. This provides a comprehensive solution to address this challenge by leveraging state-of-the-art artificial intelligence (AI) techniques. The AI-Powered Object Detection and OCR techniques aims to create a secure and trustworthy environment

during parking, ensuring safe and reliable management of a parking space for academies or companies.

YOLOv8 that trained on various custom datasets, enabling it to learn and generalize patterns by exposing it to real-time environment. The Convolutional Neural Network (CNN) backbone serves as a feature extractor, learning essential patterns from input images, in this case the numberplates from vehicles.

We trained multiple YOLO models using different datasets to assess the performance of the models trained using different yolo wieghts. But we were unable to train a model using the YOLO large weights because of the heavy computational requirement which we were unable to access. Each model returned different performance and the model with the highest accuracy was selected.

TABLE I
DIFFERENT YOLO WEIGHTS

Model	Accuracy
Nano model with dataset 1	93.32%
Medium model with dataset 1	94.72%
Medium model with dataset 2	96.56%
Large model with dataset 2	?

D. Object Detection

The system begins by capturing real-time video using a camera positioned in the college parking area. This video stream is continuously fed into the system for processing. Each frame of the video is analyzed to detect vehicles entering or leaving the premises. Utilizing a custom YOLO model, the system identifies and tracks vehicle number plates in the video frames. Once a number plate is detected, the system crops and preprocesses the image, applying techniques like grayscale conversion and thresholding to enhance character recognition. The processed number plate image is then passed through an OCR (Optical Character Recognition) engine, such as EasyOCR, to extract the alphanumeric characters representing the plate number. Simultaneously, a line is drawn over the video frame to detect when the midpoint of the number plate aligns with the line, indicating the reading of the plate's characters. This event triggers timestamp recording, marking the vehicle's entry or exit time.

E. Classification

The classification of ParkIt system has undergone a significant transformation with the integration of artificial intelligence (AI). By leveraging a dataset that has been meticulously annotated in Roboflow, the system can effectively distinguish between number plate and the background the various conditions. The system sucessfully identify the number plates of all kinds of vehicles.

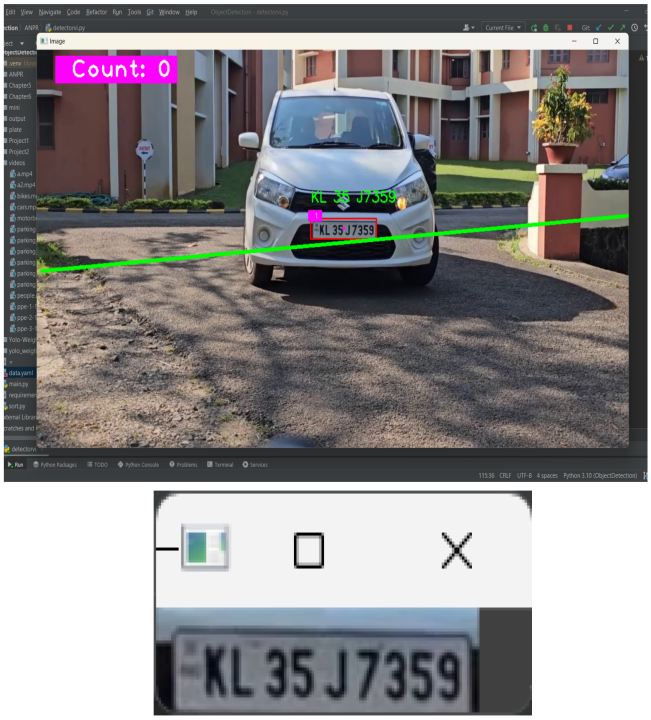

Fig. 3. Predicted Output From the Model

F. Output and Utilization

The utilization of automated parking registry powered by AI not only provides a secure and congestion free parking space but also improves the overall efficiency and saves a lot of time. With AI technology, institutions can automate the parking registry, saving time for both employees or students and the companies or management. This streamlined approach enhances the time required in parking space while maintaining the security and seamless access.

Along with real-time detection, the vehicle numbers that are entering, currently present and already left vehicles are also saved in database for later reference and can be seen using the user interface provided.

IV. IMPLEMENTATION AND RESULT

A. Implementation

The ParkIt project has achieved significant milestones in automating parking management through a combination of custom YOLOv8 model training, image preprocessing, OCR techniques, and database integration. Real-life video footage from the college parking area was used to train a custom YOLOv8 model specifically tailored to detect vehicle number plates. Following detection, the number plates were cropped, resized, and subjected to preprocessing techniques like grayscale conversion and thresholding to enhance OCR accuracy. EasyOCR and Tesseract was then employed to extract text from the processed number plate images.

A centralized system with a good graphical processor act as the central hub of the entire system which houses an object detection model(YOLOv8)and an optical character recognition model(EasyOCR or Tesseract)

B. Performance Evaluation

The ParkIt project has undergone rigorous evaluation to assess its effectiveness in automating parking management tasks. The performance evaluation encompasses several key aspects, including vehicle number plate detection accuracy, OCR precision, and system robustness.

For Number-plate Detection,we have trained multiple YOLO models with different weights and datasets providing the performance parameters as shown in Table 1.

The custom-trained YOLO model demonstrates commendable accuracy in detecting vehicle number plates from real-life video footage captured in the college parking area. Through extensive testing, the system consistently achieves high detection rates, accurately identifying vehicles entering and exiting the premises.

As per the performance, the model is capable of recognizing most of the number plates correctly (Table 1), but still, there are limitations for the model, its effectiveness for number plate detection may be influenced by various factors such as plate size, design variability, lighting conditions, and background complexity. Understanding these limitations is crucial for implementing appropriate strategies to improve the accuracy and reliability of number plate detection

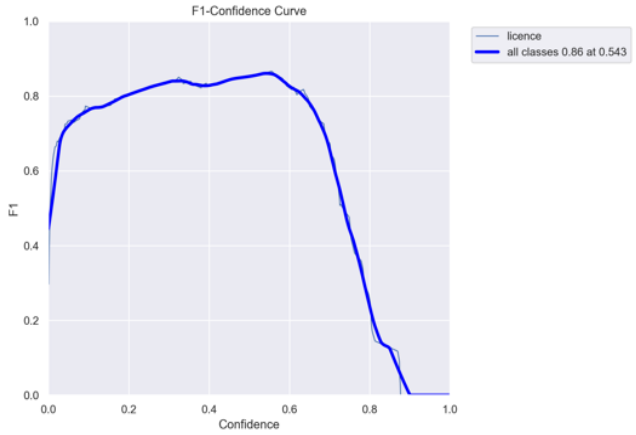

Fig. 4. F1-score of YOLOv8 medium model

The ParkIt project employs both Tesseract and EasyOCR for optical character recognition (OCR) to extract alphanumeric characters from vehicle number plates. While both OCR engines offer capabilities in character recognition, the performance evaluation indicates a preference for EasyOCR due to its superior accuracy and reliability in the context of the automatic parking registry system.

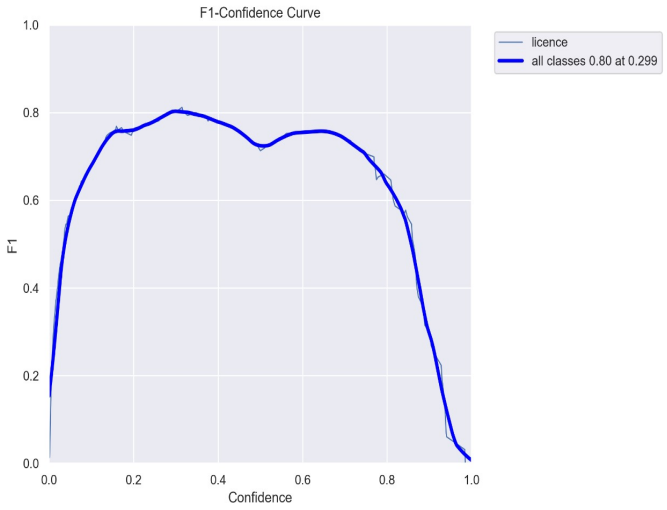

Fig. 5. F1-score of YOLOv8 nano model

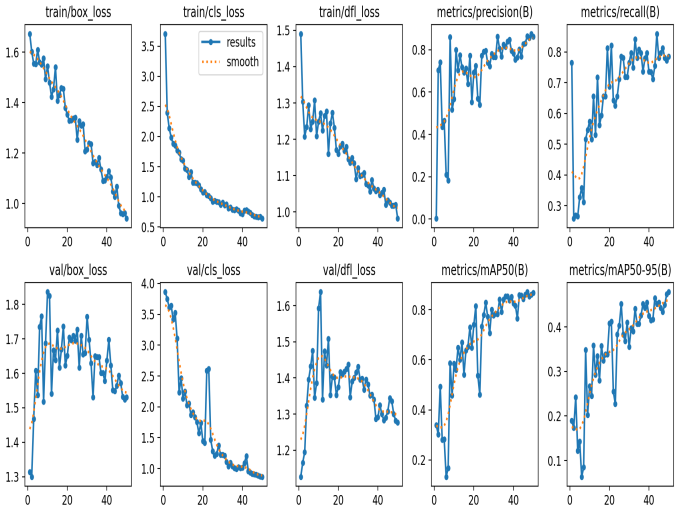

Fig. 6. Results after training model

Tesseract detected number plate edges as characters like [, / , etc. EasyOCR also had minor issues in detecting some specific characters. The integration of EasyOCR for optical character recognition enhances the system's capability to accurately extract alphanumeric characters from detected number plates. Despite challenges such as variations in lighting and plate orientation, the OCR engine effectively recognizes vehicle registration numbers, contributing to the system's reliability in maintaining an accurate parking registry.

Performance evaluation highlights EasyOCR as the preferred choice within the ParkIt project, demonstrating superior performance and reliability in character recognition tasks related to automatic parking registry management. Continued monitoring and evaluation of OCR engine performance will inform future optimization efforts to further enhance the system's effectiveness and user satisfaction.

Fig. 7. Comparioson between EasyOCR and Tesseract

C. Findings

1) High Detection Accuracy: The custom-trained YOLO model demonstrated a high Mean Average Precision (mAP) score, ensuring reliable and accurate detection of number plates in various conditions.
2) Efficient OCR Performance: The EasyOCR system exhibited robust text recognition capabilities, effectively extracting alphanumeric characters from number plates with a high degree of accuracy.
3) Real-time Monitoring: The system's ability to store in-time and out-time information for vehicles in real-time allows for efficient tracking and management of parking space usage, significantly enhancing operational efficiency.
4) Integration with Databases: Seamless integration with Firebase Realtime Database and Firestore ensures reliable and quick data storage and retrieval, facilitating effective management of parking data and user information.
5) User-friendly Interface: The system offers an intuitive and accessible user interface, enabling users to easily register vehicles, track vehicle details, view parking logs, and monitor current and left vehicles, thereby simplifying the management process for both users and administrators.

D. Comparison with State-of-the-Art Methods

In the domain of automated parking management systems, leveraging advanced deep learning models for real-time detection and analysis has become increasingly essential. The "ParkIt" system integrates several state-of-the-art components, particularly utilizing the YOLO (You Only Look Once) model for number plate detection. YOLO provides real-time object detection with impressive accuracy and efficiency, making it ideal for identifying and tracking vehicles in a parking lot. The custom-trained YOLO model employed in "ParkIt" ensures high precision and speed, setting a benchmark for parking management systems.

The system also incorporates EasyOCR for text recognition from the detected number plates. EasyOCR is known for its robust performance in recognizing alphanumeric characters across various fonts and languages, ensuring reliable and accurate extraction of vehicle registration numbers.

Compared to traditional manual registry methods and other existing automated systems, "ParkIt" offers several advantages:

- **Accuracy and Speed:** The combination of YOLO and EasyOCR ensures high accuracy and rapid processing, significantly reducing the chances of errors in vehicle detection and number plate recognition.
- **Real-time Monitoring:** The system's ability to store in-time and out-time information for vehicles in real-time enhances operational efficiency and allows for effective space management.
- **User-friendly Interface:** "ParkIt" provides an intuitive interface for users to easily register vehicles, track vehicle details, view parking logs, and monitor current and left vehicles, simplifying the overall management process.

These state-of-the-art methods employed in "ParkIt" demonstrate a significant improvement over existing solutions, offering a comprehensive, accurate, and efficient parking management system.

V. Conclusion

The ParkIt system heralds a new era in parking management and security, offering an AI-enabled automated solution that streamlines vehicle registration and monitoring processes. Leveraging a custom YOLO model for number plate detection and integrating advanced image preprocessing and Optical Character Recognition (OCR) techniques, ParkIt achieves unprecedented levels of accuracy and efficiency in registering vehicles entering and leaving parking facilities. One of ParkIt's standout features is its real-time processing capability, swiftly capturing and analyzing vehicle data as it happens. The system seamlessly stores relevant information such as plate numbers and timestamps in Firebase and Firestore databases, enabling instant access and continuous monitoring. This agile and accurate data processing not only optimizes parking space utilization but also enhances security measures and provides administrators with valuable insights for effective parking facility management. Coupled with a user-friendly web interface, ParkIt revolutionizes the parking experience for users and administrators alike, marking a significant advancement in modern parking infrastructure.

A. Future Scope

The ParkIt application has tremendous potential for further enhancements and expansion. Some of the future scopes include:

1) **Scalability for Large Parking Spaces**: Adapting the system for large private parking areas involves optimizing hardware resources and data processing algorithms

to efficiently handle a higher volume of vehicles entering and exiting the premises. This scalability ensures that the system remains responsive and accurate even during peak times, maintaining a seamless parking experience for users across diverse parking infrastructures.

2) **Optimal Parking Slot Identification:** Developing a feature to identify optimal parking slots requires leveraging machine learning algorithms to analyze real-time parking data such as slot availability, vehicle sizes, and traffic patterns. By suggesting the most suitable parking spots to incoming vehicles, the system can significantly reduce congestion, minimize search time for drivers, and improve overall parking space utilization efficiency.
3) **Automated Parking Fee Collection:** Introducing automated fee collection functionalities involves integrating payment gateways and transaction processing systems into the parking management system. This automation streamlines the payment process for users, eliminates the need for manual fee collection, reduces waiting times at exit points, and enables seamless revenue tracking and management for parking operators.
4) **Vehicle Location Interface:** Implementing a vehicle location interface allows users to easily find their parked vehicles within the parking area. This feature can utilize real-time tracking technologies such as GPS or RFID to pinpoint the exact location of each parked vehicle, providing users with accurate directions and reducing time spent searching for their cars.
5) **Dark Channel Prior Algorithm for Image Dehazing:** Incorporating the dark channel prior algorithm enhances system robustness by improving image visibility in adverse weather conditions such as rain or dust. By automatically dehazing captured images of vehicles and number plates, the system ensures accurate and reliable data processing even in challenging environmental scenarios, maintaining high levels of performance and security in parking management operations.

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