Grenze International Journal of Engineering and Technology, January Issue

Automated Vehicle Entry Management System using ANPR and OCR Technologies

S. Hemamalini[1], S. Bhoomika[2] and Dr. K. Vijayakumar[3]
[1-3]St. Joseph's Institute of Technology/Information Technology, Chennai, India
Email: malushan2810@gmail.com, bhoomikasudhakar1@gmail.com, hodit@sthosephstechnology.ac.in

***Abstract*—An Automated Vehicle Entry System is designed to streamline vehicle entry record maintenance on our college campus. This system employs Automated Number Plate Recognition(ANPR) combined with Optical Character Recognition to detect and classify vehicles with their number plates in real time. A pre-trained YOLOv9 model is used to detect vehicles in video frames, while a custom-trained YOLOv9 model specifically detects license plates. OCR techniques extract text from the plates to classify on- and off-campus vehicles. External vehicle data is cross-checked with the mParivahan application, and entry-exit records are logged into an Excel sheet using the openpyxl library. OpenCV-based image preprocessing enhances OCR accuracy, providing an automated, efficient solution with minimal human intervention.**

***Index Terms*—Automated Vehicle Entry, ANPR, OCR, YOLOv9, OpenCV, License plate detection, Vehicle Classification, mParivahan, openpyxl, OpenCV, Image preprocessing.**

I. INTRODUCTION

Managing vehicle access and departure at large institutions like college campuses, schools, and public malls is developing to become more efficient, dependable, and safe in an era where automation is fast transforming numerous sectors. Conventional car management systems mostly depend on security staff to manually record vehicle information, confirm users' identities, and keep records. These systems are prone to inaccuracies, lengthy processing times, and security risks since they frequently experience human error, delays, and inefficiency. We created a model using AI-based YOLOv9 models, Automated Number Plate Recognition (ANPR), and Optical Character Recognition (OCR) for our college campus in order to address these issues.

This project was made for the car management system of a college. There is a decreased possibility of human error and more process robustness because humans are not needed in this process. Using the pre-trained YOLOv9 model, our system is able to identify the car from the video stream. For license plate detection, the modified YOLOv9 model is used, which fixes the most applicable ROI.Further, this model's output is fed into OCR technology, which reads the image of the licenseplate, extracts the text from it, and classifies the car as being either external or on campus.

The system incorporates with the external application, namely mParivahan. Once the vehicle is detected as an external transport, the extracted vehicle number is used to check the detail about the vehicle from the mPharivan application. This method also allows us to cross-check the vehicle registration details, thus adding an extra security.

Grenze ID: 01.GIJET.11.1.26

This system logs all the entry and exit data, including the vehicle data extracted from the external application, data, and entry and exit times, into a database like an Excel sheet using openyxl library. This enables the simple and straightforward maintenance of records.

OpenCV based image processing techniques are used to improve the accuracy of recognizing the license plate with much precision. This is done to overcome unexpected situation like low-light condition, low-quality video, different angles, etc. Applying these preprocessing techniques enhance the system accuracy to detect and process the license plate, which leads to an improved recognition rate.

The main goal of this Automated Vehicle Entry System project is to automate the process of vehicle management in the college campus. Previously, these tasks are time-consuming, which are not user-friendly, and required more manpower. So, this automation procedure helps to reduce the human intervention, minimize errors, and be so user-friendly, thus ensuring smooth and fast entry processes. In addition to this, the project improves campus security by tracking the vehicles that are entering and exiting the campus, retrieving the details, and logging them.

Collectively, this system represents the significant advancement of the traditional vehicle management systems which offers efficient, and secure solution. It ensures that the campus can effectively monitor and manage vehicle access, while providing accurate and automated entry records that reduce the difficulty for the staff and improve overall operational efficiency. This solution highlights the ability of AI-powered systems which addresses the real-world challenges, particularly in institutions with large-scale where vehicle management need.

II. Literature Review

[1] This study shows that the number plate recognition system which uses image processing and OCR to identify vehicle number plates and ensures security. This system is used in various domain such as toll ways and parking areas that automate process like vehicle entry and fee collection. It captures the vehicle number plate and analyze it and read the character for recognition. The study describes the network architecture for ANPR that uses template matching for identifying Indian number plates which gives 75% to 85% accuracy.

[5] This paper focus on solving the difficulties caused by local variations in plate formats. This author presents a deep learning pipeline that focus on huge range of number plate combinations from European and Asian nations. This system produce greater accuracy in the tasks by using YOLOv4 for identification and positioning of license plate and uses AlexNet or R-CNNL3 for character recognition. This ANPR pipeline shows better accuracy and efficiency than traditional OCR based systems and its real time applications requires fast GPUs. It was created for accessing control over smart vehicles but it might be customized for more general ANPR application.

[6] The paper explores real-world UK number plates in the context of Automated Number Plate Recognition (ANPR), focusing on legislation, standards, and the impact of manufacturing techniques, materials, and fixing methodologies on image capture. Additionally, it introduces the North Iraq-Vehicle Images (NI-VI) dataset, which contains 1,500 images of vehicle plates with Arabic fonts under challenging conditions. This dataset is intended to improve the performance of ANPR systems by providing realistic scenarios for testing and development.

[8]Automating the vehicle attendance has gradually increased significantly from traditional methods like manual entry and RFID, which are often insufficient and errors will be raised. Recent advancements focuses on this using license plate recognition combined with Optical Character Recognition (OCR) and deep learning models such as Faster R-CNN to improve the accuracy and efficiency. Faster R-CNN detects and extracts from the license plate, therefore making OCR to process automatically to mark attendance. This approach eliminates the need for manual intervention, offering a faster and good solution compared to RFID-based systems. Studies show that these technologies improve the attendance tracking system, reducing the errors and processing time.

TABLE I. COMPARISON OF ANPR METHODOLOGIES

Methodology	Dataset	Accuracy	Speed	Application
OCR with Image Processing [1]	Indian plates	75-85%	Low (CPU)	Tollways, Parking Areas
YOLOv4 + AlexNet /RCNNL3 [5]	European & Asian plates	High	High (GPU)	Smart Vehicle Access
North Iraq-Vehicle Images [6]	UK plates, Arabic fonts	Varies	Moderate (GPU)	Realistic Testing
Faster R-CNN + OCR [8]	Attendance tracking scenarios	High	High (GPU)	Attendance Management

III. METHODOLOGY

The Yolov9 model automatically recognizes number plate from the vehicles that entered the college campus. The easyOCR method is used to extract the number of the number plate from the image-recognized number plate. The vehicles are classified, and their details are retrieved and stored. This work plans to implement automated vehicle entry management system using ANPR and OCR technologies with individual and serially integrated features.

A. Image Database

The data used for training the yolov9 model to detect and recognize the license plate is the ANPR2 dataset, which is provided by Roboflow.. These datasets include the images of vehicles which differs in image quality, angles, and lighting conditions, this helps in creating a model that works well in all conditions. The license plate regions are annotated with bounding boxes. This allows our model to learn plate location more accurately.

Figure 1. Example of dataset

B. Execution and Evaluation

The project begins with creating the working environment, which includes the installation of YOLOv9 and related dependencies such as OpenCV for image and video processing, OCR for text extraction from license plates, and the Roboflow API for datasets. The camera installed in the entry and exit of the college campus is used to get the input image of the vehicle which further fed into the model.

The pretrained Yolov9 model is used to detect the objects from the input image. The objects detected are the vehicle and the licence plate. The first step in this process is to detect the vehicle. YOLOv9 rapidly scans the image and accurately identify the presence of vehicles, no matter the complexity of the background or any other objects presented. Once the vehicle is detected, it is isolated for the detection of number plate.

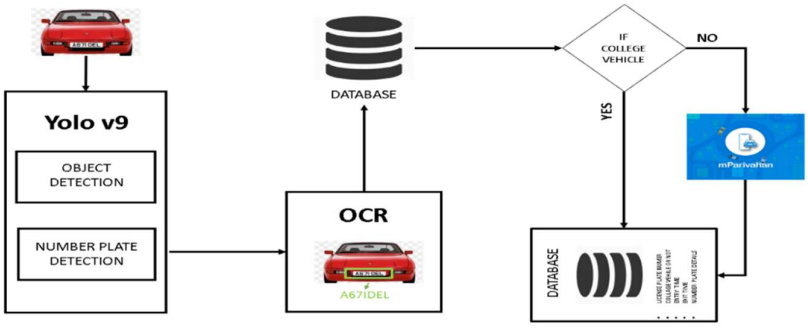

Figure 2. System Architecture

Second, equally important function is number plate detection. YOLOv9 is equipped with powerful object recognition capabilities, which is applied to locate the license plate of the detected vehicle. The model's speed and accuracy make it highly suitable for environments where vehicles move quickly or where images may be crowded . By swiftly detecting the plate, YOLOv9 ensures that the license plate can be further processed, such as being passed to an Optical Character Recognition (OCR) system for text extraction.

Once model detects the license plate, therefore the detected region is sent to Optical Character Recognition (OCR) system. The OCR's role is to extract the alphanumeric characters from the plate, such as "A671 DEL."

This text extraction is important, as the license plate serves as the vehicle's unique identifier. By converting the image of the plate into readable text, OCR automatically keeps the record, compares with databases, and further processing, such as vehicle verification or tracking, making it as a key component in systems like ANPR (Automatic Number Plate Recognition).

After the license plate number is extracted by the OCR system, it is checked against a database to determine whether the vehicle belongs to the college or is an external vehicle. The database typically contains a list of registered college vehicles, allowing for quick verification. If the plate matches an entry in the database, the vehicle is classified as a college vehicle, and it may be granted automatic access or logged accordingly. If the plate does not match, the system identifies the vehicle as an outside or visitor vehicle, potentially triggering additional security checks or entry protocols.

If the identified vehicle is a non-college vehicle, then it gets cross-checked in the internal database with the extracted license plate. The verification process is continued with the mParivahan API. mParivahan is a government platform in India that provides detailed vehicle information such as registration details, owner's name, and insurance status.

Once the system classifies that vehicle is not a college vehicle, the extracted number is used to get the related data from mParivahan by using the API key. This step is important for improving security and reducing human error as it allows the system to check whether it is safe to let the vehicle inside the campus. Thus, It makes the system robust. The data that are retrieved are stored in the database for future reference.

This ensures that non-college vehicles go through proper verification before entering the campus. It is also being recorded in the system which helps to maintain and control the security at the campus.

Once the data is processed through the college database or the mParivahan application, the results are stored in the system's database. The database stores the details of the vehicle, like whether it is a college or external vehicle, the vehicle's number plate, date and its entry & exit time. The closed-loop system ensures that all vehicle data is handled, verified, and logged in real-time, enabling automated gate control, security checks, and efficient record-keeping. This approach not only improves security but also streamlines vehicle management at the facility.

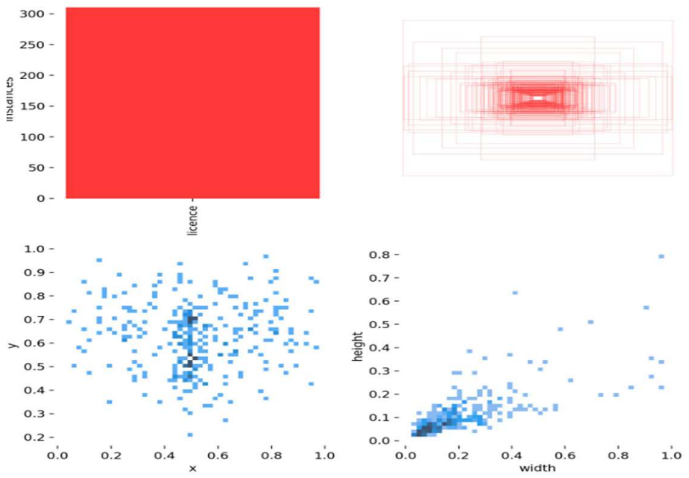

Figure 3. Labels

Figure 3 presents the output from the YOLOv9 model used in our Automated Vehicle Entry System, focusing on license plate detection and mismatches in prediction. In the top-left plot, a large red square represents the significant number of mismatches identified between predicted and actual license plates, highlighting challenges in consistent detection under varying conditions. The top-right plot illustrates the bounding box predictions made by the model, where overlapping rectangles suggest localization efforts across different regions of interest.

The bottom two scatter plots provide further insights into bounding box parameters, plotting the x and y coordinates as well as the width and height of the predicted bounding boxes. These distributions suggest that while the model accurately centers most of its predictions (visible clustering), there remains some variation in the width and height of the boxes. These results underscore the need for further refinement of the model's parameters to improve detection accuracy, particularly in challenging scenarios where plate sizes and locations vary significantly.

C. Results and Discussion

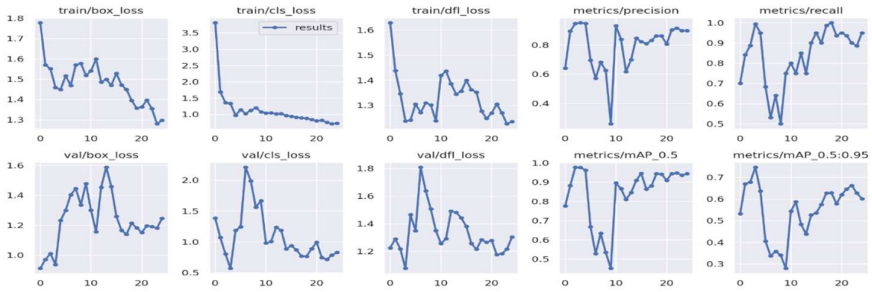

Figure 4. Training result

Figure 4 displays the training and validation metrics for a YOLOv9 model across various epochs. Key metrics such as loss functions for both the training and validation datasets are shown, including box loss, classification loss (cls_loss), and distribution focal loss (dfl_loss). The training losses exhibit a general decreasing trend, suggesting that the model is learning effectively over time. Validation losses are more erratic but also show some reduction. Precision, recall, and mean Average Precision (mAP) metrics provide insight into the model's performance: precision and recall improve over epochs, while mAP metrics demonstrate moderate variability, stabilizing after an initial dip. Overall, the model shows positive learning behavior with room for further optimization in validation performance.

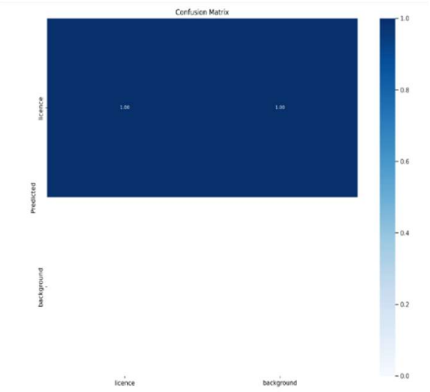

Figure 5. Confusion matrix

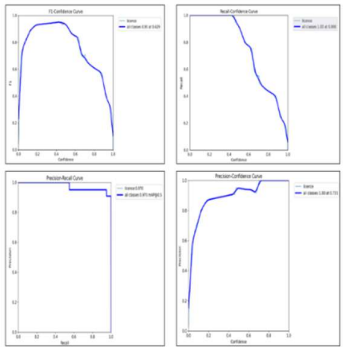

Figure 6. Evaluation curves

Figure 5 indicates perfect classification performance for both "license" and "background" categories. Each predicted class is correctly matched with its corresponding true label, with values of 1.00 along the diagonal, demonstrating 100\% accuracy. There is no incorrect classifications between the "license" and "background" categories, as seen by the absence of any off-diagonal elements. This result highlights the model's strong ability to differentiate between these two classes, likely due to effective feature extraction and model tuning.

Figure 7. License plate detection

Figure 8. OCR

Figure 7 showcases the YOLOv9 model's performance in detecting and classifying license plates. In both instances, the model successfully identifies the license plates, with confidence scores of 0.98, 0.93, and 0.57. The high confidence in the first detection (0.98) suggests the model's strong ability to recognize license plates in clear conditions. In the second image, the model detects two license plates, with slightly lower confidence for one (0.57), this could be due to factors like lighting or angle. In spite of this, the model demonstrates accurate localization, effectively bounding the regions of interest. This results in the strength of the YOLOv9 model in license plate detection. We can make slight improvements to enhance confidence in critical cases.
Figure 8 represents the output of an OCR (Optical Character Recognition) system applied to an automated vehicle license plate recognition task. The detected license plate reads "KA 02 MM9091," with the OCR system accurately extracting the alphanumeric characters from the vehicle's license plate. The system handles various unpredictable conditions. This application of OCR is particularly useful in Automated Number Plate Recognition (ANPR) systems, which play an important role in vehicle entry systems. The extraction of vehicle registration numbers ensures data retrieval for future reference, security and automated vehicle access control.

IV. Conclusions and Future Directions

The System combines YOLOv9 for real-time vehicle and license plate detection, combined with Optical Character Recognition (OCR) vehicle management and enhances campus security. By using accurate text extraction, the System offers a highly efficient solution for recording and managing vehicle access. For external data verification, we use the mParivahan application., The image is pre-processed with an openCV library which helps to improve system performance. This reduces human errors, which leads to a more effective automated vehicle entry management process.
Future enhancement involves expanding its capabilities to recognize and count individuals inside the vehicle, thereby providing an additional layer of security and verification. Currently, the system identifies only the vehicle and retrieves details about its registered owner; however, this does not confirm the identities of the occupants entering the campus. By implementing occupant recognition, the system could ensure that only authorized persons are allowed access, regardless of vehicle ownership. This would address situations where the person entering may not be the vehicle owner, strengthening campus security by ensuring that every individual within each vehicle is identified and logged accurately. Such enhancements would improve the system's reliability in monitoring and managing campus access

References

[1] A. Kashyap, B. Suresh, A. Patil, S. Sharma and A. Jaiswal, "Automatic Number Plate Recognition," 2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida, India, 2018, pp. 838-843, doi: 10.1109/ICACCCN.2018.8748287.

[2] A. S. Shetty, V. S. Vineeta, S. Ravi, N. Likhitha and K. Anuradha,"Vehicle Number Plate Detection through live stream using Optical Character Recognition (OCR)," 2023 7th International Conference on Trends in Electronics and Informatics (ICOEI), Tirunelveli, India, 2023, pp. 1548-1553, doi: 10.1109/ICOEI56765.2023.10125986.I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[3] Harish Rapartiwar, Pushpanjali Shivratri, Omkar Sonakul, Ashwini Bhugul, "Visitor Gate Pass Management System", IJCSMC, Vol. 6, Issue. 2, February 2017, pg.170 – 178

[4] K. Jain, T. Choudhury and N. Kashyap, "Smart vehicle identification system using OCR," 2017 3rd International Conference on Computational Intelligence & Communication Technology (CICT), Ghaziabad, India, 2017, pp. 1-6,

[5] M. G. Khan, Salma, M. Saeed, A. Zulfiqar, Y. Y. Ghadi and M. Adnan, "A Novel Deep Learning Based ANPR Pipeline for Vehicle Access Control," in IEEE Access, vol. 10, pp. 64172-64184, 2022, doi: 10.1109/ACCESS.2022.3183101.

[6] M. Rhead, R. Gurney, S. Ramalingam and N. Cohen, "Accuracy of automatic number plate recognition (ANPR) and real world UK number plate problems," 2012 IEEE International Carnahan Conference on Security Technology (ICCST), Newton, MA, USA, 2012, pp. 286-291, doi: 10.1109/CCST.2012.6393574.

[7] Osakwe Anthony Abuchi, Dr. Arul Lenna Rose .P.J, Dr. Aarthi. E, ``Application of Machine Learning for Automatic Number Plate Recognition Using Optical Character Recognition Engine".

[8] P. Bhavani, S. Vaishnavi, P. Vennila, V. Vijayalakshmi , ``Bus Attendance System using Optical Character Recognition," Volume-9 Issue-4, April, 2020.

[9] X. Zhai, F. Bensaali and R. Sotudeh, "OCR-based neural network for ANPR," 2012 IEEE International Conference on Imaging Systems and Techniques Proceedings, Manchester, UK, 2012, pp. 393-397, doi: 10.1109/IST.2012.6295581.

[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.