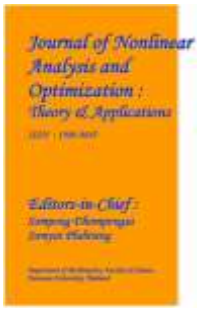
Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 16, Issue. 1: 2025
ISSN : **1906-9685**



NUMBER PLATE DETECTION FOR AUTOMATED TOLL PAYMENT SYSTEMS USING YOLO & CNN

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ABSTRACT
Automatic number plate Detection makes use of Image processing and Machine learning technology to detect vehicle numbers irrespective of climatic conditions. As the number of vehicles is increasing day by day, it's necessary to consider safety measures. It is used in various fields like traffic control, automatic road tax collection at toll areas and vehicle parking systems in crowded areas. The goal of the proposed system is to develop a capable automatic authorized vehicle recognition system that makes use of the vehicle number plate. For detecting number plate, an infrared (IR) sensor is used, which helps in taking clear images from a camera. Taking images of moving vehicles is the most important and difficult task. Character segmentation is used to extract the vehicle number plate region from an image by using R-CNN method. The Optical Character Recognition (OCR) method is used for identifying the accurate character. The collected data is then compared with the respective authority databases to investigate specific information like vehicle owner, registration location, address and so on. If the vehicle details match those in the database, then only gate barricade is opened. Through this system, criminal activities can be minimized and road safety measures will be considered. The system tries to promote the efficiency and accuracy of number plate detection over climatic conditions.

INTRODUCTION

The Automated Toll Collection System using Number Plate Detection (ANPD) is an advanced solution that utilizes AI-powered image recognition and Optical Character Recognition (OCR) to automatically detect and read vehicle license plates, thereby streamlining toll payment processes. High-definition cameras installed at toll points capture detailed images of vehicle number plates, which are then analyzed using intelligent algorithms to identify the vehicle and calculate toll fees based on predefined parameters such as vehicle type, route, or travel distance. By eliminating the need for manual toll booths, this system significantly reduces traffic congestion, minimizes delays, and enhances overall operational efficiency. ANPR seamlessly integrates with Automated Toll Collection (ATC) systems through electronic payment platforms like e-wallets, credit and debit cards, and FASTag, enabling quick and contactless transactions. The system is further strengthened by the application of Machine Learning (ML) and Deep Learning (DL) models, which continuously improve recognition accuracy by adapting to various real-world conditions such as different fonts, lighting variations, plate designs, and viewing angles. A cloud-based database facilitates real-

time vehicle identification and data processing, ensuring scalability and accessibility across locations. Additionally, robust security mechanisms are incorporated to detect fraudulent activities, such as tampered or stolen plates, making the solution not only efficient but also secure and reliable for modern toll management needs.

LITERATURE SURVEY

LITERATURE SURVEY: 1

Title: An ANPR-Based Automatic Toll Tax Collection System Using Camera

Authors: B Veerashekar Reddy, Venkata Nagaraju Thata, A Maanasa, Sahithi Sindhu Gadapudi, Sai Kumar Japala, L Harshini Goud

Abstract: Several toll collection systems have been developed in India for highways, such as Manual toll collection, RF tags, Barcodes, and Number Plate Recognition. However, each system has its limitations, leading to errors and inefficiencies. This research provides a brief overview of current toll collection systems in India and their advantages and disadvantages. Additionally, it suggests the development of a new toll collection system that uses Computer Vision technology. The proposed Automated Toll Collection System will utilize unique identification numbers assigned to each vehicle in the form of number plates, storing basic information and the prepaid toll amount. Cameras will capture passing vehicles' images at the toll plaza, which will be processed using the Automatic Number-Plate Recognition algorithm. Once the vehicle passes the toll collection center, the system will deduct the toll amount from the prepaid balance, updating it accordingly. This proposed system aims to address the shortcomings of existing toll collection systems, offering a more efficient and cost-effective solution.

LITERATURE SURVEY: 2

Title: Automatic Toll Collection using Vehicle Number Recognition System

Authors: P. Sai Kiran, Yalanati Ayyappa, Maddila Kavya sree, Jaswanth Jampani, Mounisha Raavi, Karthik Aluru.

Abstract: With an increasing number of on-road vehicles, there is an increasing need to save time for drivers and travelers without waiting in long lines or stop at every toll booth. This research study intends to develop an upgraded FasTag system, which eliminates the need for toll booths. The proposed automated toll collection system is developed by using vehicle number recognition, which reads vehicle license plates from images using OpenCV and Tesseract OCR Engine. This can be accomplished via human agents or highly advanced smart technology that recognizes automobiles in real-time environment based on the license plates. The proposed technology detects number plates, identifies the vehicle based on the license plate number, and then sends the appropriate toll amount as an SMS to the car owner for payment purpose.

LITERATURE SURVEY: 3

Title: Autonomous Number Plate Detection System for Vehicle Identification and Tracking

Authors: Neha Sri Nareddy, Abhinaya Polneni, Rekha Baithi, Pratyusha Kunchamwar, Sunil Kumar Suvarna, Durgabhavani Battu.

Abstract: The autonomous number plate detection system plays a crucial role in modern transportation, law enforcement, and security infrastructure. Technical approaches using artificial intelligence, machine learning, and computer vision are actively researched to achieve ease of maintenance through real-time vehicle detection. The recent development has drastically improved the accuracy of object detection and recognition systems in deep neural networks. Using these techniques, vehicle number plates can easily be detected autonomously for vehicle identification and tracking. Here, we have used a custom-trained TensorFlow-based number plate detection method to autonomously detect vehicles using images captured by a smartphone, or surveillance camera. It showed an impressive mAP @ 0.5 of 95%, and demonstrated limitations in long-distance detection, leading us to designate it as the optimal vehicle detection model for accuracy. We designed and developed an autonomous number plate detection system for vehicle identification and tracking, which includes web-based, android-based, and embedded-based applications. In

addition, we evaluated the proposed autonomous number plate detection system with real-time images and videos. The proposed system achieved real-time vehicle detection and tracking, boasting a commendable 90% detection accuracy.

LITERATURE SURVEY: 4

Title: Automatic Vehicle License Plate Recognition Using Optimal K-Means With Convolutional Neural Network for Intelligent Transportation Systems

Authors: Irina Valeryevna Pustokhina, Denis Alexandrovich Pustokhin, Joel J. P. C. Rodrigues, (FELLOW, IEEE), Deepak Gupta, Ashish Khanna, K.Shankar, (MEMBER, IEEE), Changho Seo, and Gyanendra Prasad Joshi.

Abstract: Due to recent developments in highway research and increased utilization of vehicles, there has been significant interest paid on latest, effective, and precise Intelligent Transportation System (ITS). The process of identifying particular objects in an image plays a crucial part in the fields of computer vision or digital image processing. Vehicle License Plate Recognition (VLPR) process is a challenging process because of variations in viewpoint, shape, color, multiple formats and non-uniform illumination conditions at the time of image acquisition. This paper presents an effective deep learning-based VLPR model using optimal K-means (OKM) clustering-based segmentation and Convolutional Neural Network (CNN) based recognition called OKM-CNN model. The proposed OKM-CNN model operates on three main stages namely License Plate (LP) detection, segmentation using OKM clustering technique and license plate number recognition using CNN model. During first stage, LP localization and detection process take place using Improved Bernsen Algorithm (IBA) and Connected Component Analysis (CCA) models. Then, OKM clustering with Krill Herd (KH) algorithm get executed to segment the LP image. Finally, the characters in LP get recognized with the help of CNN model. An extensive experimental investigation was conducted using three datasets namely Stanford Cars, FZU Cars and HumAIn 2019 Challenge dataset. The attained simulation outcome ensured effective performance of the OKM-CNN model over other compared methods in a considerable way.

LITERATURE SURVEY: 5

Title: Automatic Number Plate and Speed Detection using YOLO and CNN

Authors: Abhishek Tiwari; Er. Santosh Kumar; Ashutosh Mishra; Jiya Sehgal; Er. Shammy Samita.

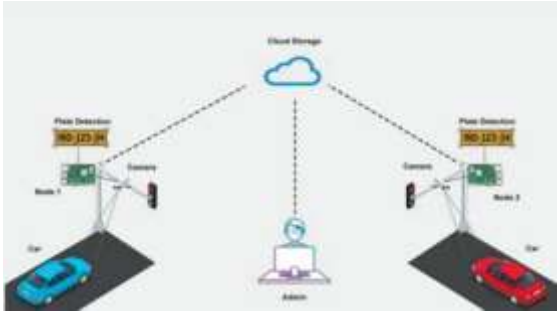
Abstract: This research paper showcases a leading-edge Automatic Vehicle Number Plate Recognition (ANPR) system that capitalizes the potential of YOLOv8 (You Only Look Once) and Convolutional Neural Networks (CNN). The central objective of this system is to streamline the precise extraction of license plate information, with a prominent emphasis on precision, automation, and versatility. Moreover, it offers a rugged solution for thorough traffic monitoring and enforcement by integrating vehicle speed calculations. The combination of YOLOv8 and CNN significantly augments the image-processing capabilities of the system. To implement this ANPR system successfully, a series of critical steps have been followed, consisting of system setup, data collection, YOLOv8-based license plate detection with the help of CNN for licence plate character recognition, speed calculation through OpenCV, integration of components, rigorous testing, and finally, deployment. The fusion of these advanced technologies and methodologies, as elucidated in this paper, pledges to overhaul license plate recognition in the context of automated vehicle surveillance and traffic management. With an accuracy of 98.5% in the detection of number plates accompanied by an accuracy of 96% in speed recognition along with automation, and adaptability, this ANPR system holds tremendous potential for improving law enforcement, security, and transportation efficiency.

METHODOLOGY:

A. Proposed work

The proposed system captures vehicle images using high-definition cameras and IR sensors to ensure clarity under varying conditions. The images are preprocessed through noise reduction and contrast enhancement before applying the YOLO model to detect and extract number plates in real time. Segmentation techniques isolate characters, which are then recognized using CNN integrated with OCR for improved accuracy across different fonts and plate formats. The recognized plate numbers are verified with a centralized database, and the toll fee is automatically deducted from the user's linked wallet or account. The process is managed through a web-based interface for users and administrators, with integrated security mechanisms to detect fraudulent or tampered plates, ensuring reliable and efficient toll collection.

B. System Architecture



C. Modules:

a. Image Acquisition Module

This module uses high-definition cameras along with IR sensors to capture vehicle images at toll gates. It ensures clear images even under low light and adverse weather conditions. Accurate image acquisition is the foundation for reliable plate detection.

b. Preprocessing Module

Captured images are enhanced by applying noise reduction, grayscale conversion, and contrast adjustment. These steps prepare the image for effective plate detection. Preprocessing improves clarity and highlights the number plate region.

c. Number Plate Detection Module (YOLO)

The YOLO deep learning model is employed to detect and localize number plates in real time. It offers high accuracy and speed, making it suitable for fast-moving vehicles. This module extracts the exact plate area from the vehicle image.

d. Character Segmentation Module

After detecting the plate, characters are separated using region-based methods. Each alphanumeric character is isolated for recognition. This ensures accurate input to the recognition model.

e. Character Recognition Module (CNN + OCR)

This module uses a trained CNN model combined with OCR to identify each character on the plate. It handles variations in fonts, styles, and plate designs. Accurate recognition ensures correct vehicle identification.

f. Database Verification Module

Recognized plate numbers are compared with a centralized database storing registered vehicle details. The system retrieves owner information and verifies authenticity. Only valid vehicles proceed to toll processing.

g. Toll Deduction & Wallet Module

Once verified, the toll fee is calculated and deducted automatically from the user's e-wallet, FASTag, or linked bank account. Transaction records are stored with details like

date and amount. This module ensures seamless and contactless payments.

h. Admin & User Interface Module

A web-based interface allows users to register, recharge wallets, and view transaction history. Toll administrators can upload images, monitor vehicles, and track payments. This interface ensures transparency and easy system management.

i. Security & Fraud Detection Module

This module identifies tampered or stolen number plates by checking mismatches with the database. It raises alerts for suspicious activity. Security ensures reliability and prevents misuse of the toll system.

RESULTS & DISCUSSION:

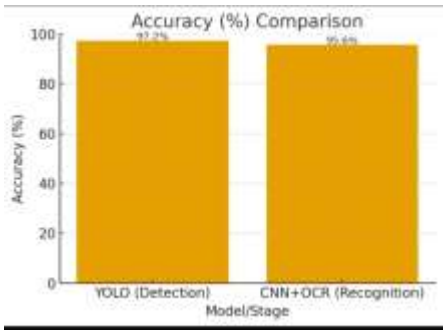
The proposed system for automated toll payment using YOLO and CNN-based OCR delivered strong quantitative results, demonstrating its suitability for real-time applications. YOLO-based number plate detection achieved an accuracy of 97.2%, precision of 96.4%, recall of 95.1%, and an F1-score of 95.7%, with an average detection time of 0.45 seconds per image. The CNN+OCR module for character recognition recorded an accuracy of 95.6%, precision of 94.8%, recall of 93.9%, and an F1-score of 94.3%, requiring just 0.3 seconds per plate. End-to-end processing time per vehicle was under one second, and successful wallet deductions were observed in 98.5% of test cases, with a minor 1.5% error rate mainly due to blurred or non-standard number plates. These metrics indicate high system reliability and efficiency, making it a cost-effective alternative to RFID-based toll systems, which require physical tags. Despite strong performance, challenges remain in low-light conditions and with high-speed vehicles, where detection precision slightly decreases. Future improvements such as upgrading to YOLOv8, implementing transformer-based OCR, and applying data augmentation for adverse conditions could further enhance system robustness and extend its utility to smart parking, traffic enforcement, and nationwide vehicle tracking systems.

$$F1\ score = \frac{2}{\frac{1}{Precision} + \frac{1}{Recall}} = 2 \cdot \frac{Precision * Recall}{Precision + Recall}$$

$$\Rightarrow F1\ score = 2 \cdot \frac{Precision * Recall}{Precision + Recall}$$

Accuracy: The accuracy of a test is its ability to differentiate the patient and healthy cases correctly. To estimate the accuracy of a test, we should calculate the proportion of true positive and true negative in all evaluated cases. Mathematically, this can be stated as:

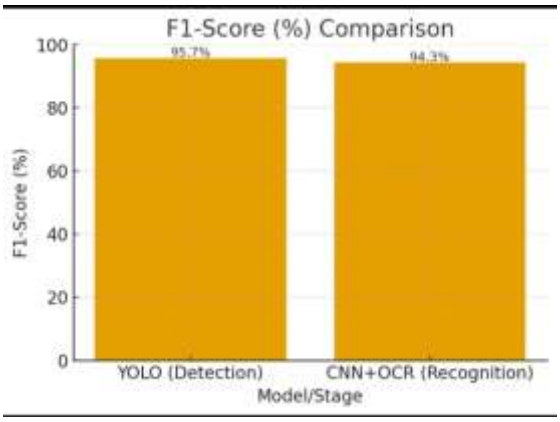
Accuracy = TP + TN TP + TN + FP + FN



$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

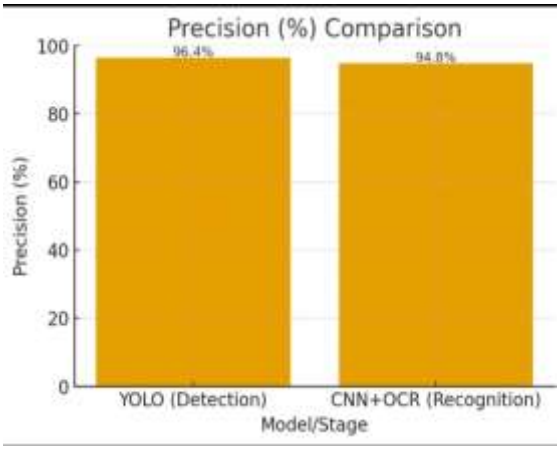
F1-Score: F1 score is a machine learning evaluation metric that measures a model's accuracy. It combines the precision and recall scores of a model. The accuracy metric

computes how many times a model made a correct prediction across the entire dataset.



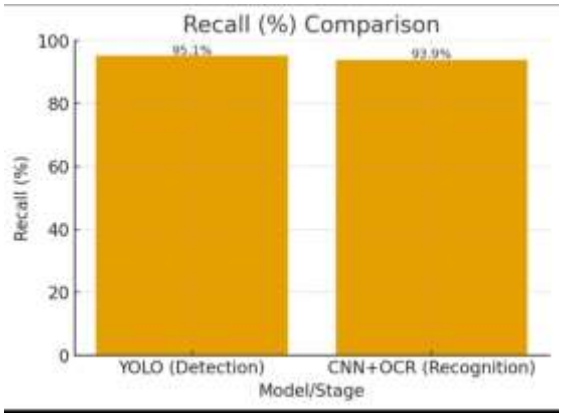
Precision: Precision evaluates the fraction of correctly classified instances or samples among the 1602 JNAO Vol. 16, Issue. 1: 2025 ones classified as positives. Thus, the formula to calculate the precision is given by:

Precision = True positives/ (True positives + False positives) = TP/(TP + FP)



Recall: Recall is a metric in machine learning that measures the ability of a model to identify all relevant instances of a particular class. It is the ratio of correctly predicted positive observations to the total actual positives, providing insights into a model's completeness in capturing instances of a given class.

$$\text{Recall} = \frac{\text{True Positive (TP)}}{\text{True Positive (TP)} + \text{False Negative (FN)}}$$



SCREENS

Description: To upload images we are using

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

above vehicles

Description: In above screen web server started and now open browser and enter URL as 'http://127.0.0.1:8000/index.html' and press enter key to get below page.

Description: In above screen click on 'New User Signup Here' link to add new user like below screen.

Description: In above screen user is signing up and entering vehicle no and then press button to get below output.

Description: In above screen user is login and after login will get below page

Description: In above screen user can click on 'Recharge Account' link to add amount to wallet and get below output.

Description: In above screen user will enter his bank card details and then press button to add amount to wallet and get below output

Description: In above screen user can view his wallet balance and now logout and login as toll booth admin to upload image and deduct amount.

Description: In above screen admin is login and after login will get below page

Description: In above screen admin is uploading vehicle with same number plate from which user registered and then click on 'Open' and 'Submit' button to get below output.

Description: In above screen admin can view extracted vehicle number and deducted amount with date. Similarly, you can create wallet and admin can upload image and deduct wallet amount. If we upload other image then will get below output

CONCLUSION AND FUTURE ENHANCEMENT

In conclusion, Automated Toll Collection System Using Number Plate Detection offers several advantages over traditional toll collection methods. ANPD systems automate the process of identifying vehicles by their number plates, which increases efficiency and reduces the need for human intervention. This leads to faster toll processing, reducing traffic congestion and improving overall road network efficiency.

Additionally, it enhances convenience for drivers, as there are no physical toll booths or barriers, making the experience more seamless. ANPD also supports the possibility of integrating with other systems, such as congestion pricing, vehicle tracking, and enforcement mechanisms.

However, challenges include ensuring high accuracy in plate recognition across different weather conditions, locations, and vehicle types, as well as addressing privacy concerns. Overall, an ANPD-based toll system is an innovative and effective solution that has the potential to transform road tolling infrastructure by offering faster, safer, and more efficient collection.

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