IDENTIPLATE: An Android-Based Automatic License Plate Recognition and Carbon Emission Calculation on Automobile Ingress/Egress

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Keywords

Abstract

Academic institutions are not exempt from challenges in managing vehicle transportation, including traffic congestion, inefficient ingress and egress, and the resulting environmental concerns. With the rising volume of vehicles entering and exiting campuses, there is a pressing need for systems that can streamline traffic management while addressing the institution's environmental impact. This problem calls for innovative solutions that balance operational efficiency with sustainability. To address these emerging problems, IdentiPlate has been developed, an integrated system combining automatic license plate recognition (ALPR) with vehicle carbon emission calculations. The system consists of an Android app that utilizes an API for text and image recognition to automatically identify license plates and calculate carbon emissions based on variables such as emission factors, travel distances, and fuel economy data. Additionally, a web-based platform facilitates data management and tracks vehicle ingress and egress. Overall, the IdentiPlate demonstrated its ability to improve operational efficiency and promote environmental responsibility. User feedback indicates that the system was tailored to meet institutional needs, with enhancements suggested to optimize it further.

1. Introduction

Managing vehicle ingress and egress is a persistent operational challenge for academic institutions, especially those with large populations and high traffic volume. Traditional manual verification methods, such as visually checking vehicle stickers and recording entries in logbooks, are prone to delays, inaccuracies, and inefficiencies. As campuses continue to grow, the need for automated, data-driven solutions becomes increasingly evident. Beyond operational concerns, institutions also face growing environmental responsibility as transportation contributes significantly to carbon emissions, particularly in the Philippines where road transport accounts for most greenhouse gas output.

This study explores a technology-driven approach that integrates Automatic License Plate Recognition (ALPR) with carbon emission estimation to improve vehicle monitoring while contributing to campus sustainability goals. ALPR has been widely applied in traffic management, parking systems, and law enforcement; however,

its adoption in educational institutions remains limited. Moreover, existing ALPR implementations generally focus on recognition accuracy and do not extend to environmental monitoring.

The purpose of this research is to design, develop, and evaluate a monitoring system capable of automating vehicle identification through an Android-based ALPR application and generating carbon emission estimations for academic institutions.

1.1 Literature Review

Automatic License Plate Recognition (ALPR) is widely studied across domains involving security, traffic management, and intelligent transportation systems. Early methods relied on traditional image-processing techniques such as edge detection, morphological operations, and segmentation (Sandhu et al., 2022). However, accuracy was often affected by lighting, noise, and plate variations (Khan et al., 2023). Modern ALPR increasingly uses machine learning and deep learning architectures—including YOLO variants, CNNs, and OCR engines—to enhance detection and recognition reliability under varying conditions (Kim et al., 2021; Zhu et al., 2023).

Several studies evaluated OCR-based and hybrid methods for character extraction, noting limitations when characters share similar shapes (e.g., 1/I, 2/Z, B/8, 0/O) (Ancog et al., 2021; Zhang, 2020). Lightweight implementations for mobile devices have also been explored. Liew et al. (2020) and Adinugroho et al. (2021) demonstrated that smartphone-based ALPR systems are feasible but often experience accuracy drops due to camera quality and environmental factors. Mobile-oriented research in Southeast Asia shows additional challenges caused by custom license plate formats and varying plate designs (Azhar et al., 2024).

Regarding carbon emissions, transportation is a major contributor to greenhouse gases. The Philippine Department of Energy (2023) reported road transport as the leading emitter of CO_2 among all transport modes. Several studies analyzed fuel economy and carbon outputs of different vehicle types (Vergel et al., 2024; National Resources Canada, 2014; Michelin Connected Fleet, 2024). Carbon estimation models commonly use fuel consumption multiplied by emission factors (2.31 kg/L for gasoline, 2.67 kg/L for diesel).

While ALPR and carbon emission modeling are well-established individually, their combined use in academic institutions—particularly for real-time ingress/egress monitoring—has not been widely explored. This research addresses that gap by integrating ALPR-based vehicle identification with automated carbon footprint computation through a web-based system.

2. Research Methods

This study employed a descriptive research design to develop and evaluate an Android-based ALPR and carbon emission monitoring system. The methodology followed the Agile Software Development Life Cycle (SDLC), consisting of planning, design, development, testing, deployment, and review phases.

Sampling Design

Purposive sampling was used to identify respondents knowledgeable about vehicle monitoring processes and system requirements. The sample included the head of security, 20 security guards, and 9 IT experts from the institution (N = 30). These respondents participated in usability, functionality, and performance evaluations aligned with ISO/IEC 25010:2024 standards.

Data Collection

Data for vehicle registration were obtained from the Facilities Management and General Services Department, which the system used as a basis on what to collect for applicant details and vehicle documents. For evaluation of the system, a 4-point Likert scale was issued to the respondents.

System Development

The web application was built using HTML5, CSS (Bootstrap), JavaScript, PHP, and MySQL, hosted on an online server. The Android app, developed in Java via Android Studio, integrated the Plate Recognizer API for text extraction from license plate images. The system architecture included modules for vehicle registration, user management, real-time ingress/egress logging, and analytics.

Carbon Emission Calculation

Carbon emissions were computed using the formula:

$Emissions\ (kg)\ =\ (Distance\ /\ Fuel\ Economy)\ x\ Emission\ Factor$

where the emission factor was 2.35 kg/L for gasoline and 2.69 kg/L for diesel. For unregistered vehicles, the guard selected vehicle type and fuel type to apply preset average mileage values. The distance for this study is set as 0.4km with consideration of the allotted testing area being the front gate of the institution.

3. Result and Discussion

The results of the study demonstrate the effectiveness of IdentiPlate as an integrated system for monitoring vehicle ingress and egress and estimating carbon emissions within Colegio de San Juan de Letran Calamba. The findings encompass the performance of the Android-based mobile application, the functionality of the system dashboard, the accuracy of carbon emission calculations, and the system's overall compliance with ISO/IEC 25010:2024 software quality standards. Each component was tested and evaluated through controlled trials and validated through survey responses from security guards, IT experts, and the security head of the institution.

The implementation of the Android-based application revealed that the system successfully automated the recognition and verification of vehicle license plates using the PlateRecognizer ALPR API. Security guards were able to capture plate images, send them to the database, and receive immediate feedback on registration status. The ALPR feature performed strongly across various conditions, achieving a 98% daytime accuracy and an overall accuracy of 94% across all lighting scenarios. Although performance slightly decreased during nighttime without backlighting, the results still demonstrated a high degree of reliability suitable for real-world operations. Distance tests further showed that the application was capable of recognizing plates consistently from 2 to 5 meters, registering a perfect 100% accuracy in all trials. With an average processing time of 3.4 seconds per recognition, the system provided prompt responses necessary for maintaining smooth vehicle flow at the campus entry point.

Alongside the mobile application, the dashboard played a crucial role in visualizing and interpreting the recorded data. The administrator dashboard provided real-time insights on registered vehicles, unrecognized plates, vehicle counts, and carbon emission summaries. Early inconsistencies were identified in the ingress/egress timestamps due to a mismatch between the local and server time zones, but once corrected, the dashboard displayed accurate and synchronized logs. The interface for applicants was equally effective, allowing users to view their registration history, track the approval status of vehicles, and monitor their monthly carbon emissions. This functionality not only enhanced transparency but also encouraged user awareness regarding their contribution to the institution's sustainability goals.

Carbon emission calculations were integrated into the system's web application using emission factors prescribed by the United States Environmental Protection Agency (2024), specifically 2.35 kg CO_2 per liter of gasoline and 2.69 kg CO_2 per liter of diesel. During testing, gasoline-based calculations consistently produced correct results, while initial diesel computations were incorrect due to a misconfigured variable in the system. After correcting the emission factor, the dashboard accurately reflected the emissions generated by each vehicle. The availability of these calculations in both the administrator and applicant views demonstrated the system's capability to support environmental monitoring and decision-making—an important objective of the study.

User evaluation further affirmed the system's operational strength. Security guards rated the system highly in usability, with an overall weighted mean of 3.60 (Strongly Agree). They found the mobile interface easy to navigate and the data intuitive to understand. The only area rated slightly lower was the clarity of system instructions, which received a mean of 3.20 (Agree). This suggests that usability could be further improved

through structured user training and a detailed user manual—an issue linked to the researchers' limited time to orient the guards before testing. Despite this, security guards also rated the system's performance and reliability positively, with an average score of 3.70 (Strongly Agree), citing minimal errors and consistently stable operation.

Feedback from IT experts and the security head likewise reflected strong approval of the system's functionality. IT experts provided an average mean score of 3.86 (Strongly Agree), acknowledging the system's effective license plate detection, carbon emission computation, data visualization, and overall performance. The security head's evaluation also indicated a high level of satisfaction, with a mean of 3.60 (Strongly Agree). Although both groups noted occasional ALPR inconsistencies—mostly due to poor network connectivity—the system still met the requirements and expectations of the stakeholders.

In terms of security, the system demonstrated full compliance with essential data protection practices. IT experts awarded a perfect mean score of 4.00 (Strongly Agree), affirming that the system successfully prevents unauthorized access, encrypts user passwords, and implements robust identity verification. The role-based access control model effectively ensured that sensitive data could only be accessed by authorized users, adding an additional layer of protection.

Overall, the results confirm that IdentiPlate successfully accomplished its objectives. The system performed well in automating vehicle monitoring, presenting data through a functional dashboard, and estimating carbon emissions with accuracy. While minor issues were encountered—such as time zone mismatches, diesel variable misconfigurations, and the need for clearer instructions—these were resolved or identified as areas for enhancement. The strong survey results, high ALPR performance, and accurate system outputs collectively demonstrate that IdentiPlate is a reliable, functional, and secure solution that contributes both to operational efficiency and to the institution's sustainability initiatives.

4. Conclusions

This study successfully developed an integrated system that automates vehicle monitoring through Android-based ALPR and supports environmental sustainability by calculating carbon emissions during campus ingress and egress. The combination of mobile image processing, API-based text recognition, and a robust web dashboard is also noted in aiding the monitoring and management of vehicles. ALPR accuracy was influenced by lighting and distance but remained effective under most real-world conditions. The carbon emission module provided meaningful insights into transportation-related environmental impact, aiding institutional sustainability efforts.

Future research may explore post-processing of images for increased accuracy of text recognition under certain conditions and training of deep learning models for internal use of the institution, to have a more customized and feature-rich ALPR system.

5. References

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