SECURE-SCAN: LICENSE PLATE RECOGNITION FOR DETECTION OF ILLEGAL VEHICLE PLATES

Sun Bryle D. Alvarado[1], Julliah Marie Escaro[2], Roberto S. Delariarte Jr.[3], Cris John Paul A. Hisanza[4], , Shuby R. Tuante[5], John Ray F. Perez[6]

[1,2,3,4,5,6]Iloilo State University of Fisheries Science and Technology

Abstract-The Municipality of Dumangas, a progressive town in Iloilo, faces growing challenges in monitoring vehicle activities, particularly in identifying unregistered, tampered, or illegal vehicle plates. Manual vehicle inspections at checkpoints are often limited by human error, inefficiency, and delays. To address this issue, this study proposes SECURE-SCAN: License Plate Recognition for Detection of Illegal Vehicle Plates, an automated system aimed at improving public safety and traffic security within the locality.

SECURE-SCAN utilizes high-definition cameras strategically placed in key areas such as municipal checkpoints, entry points, and public establishments. Captured images undergo preprocessing for contrast enhancement and plate localization. The characters on the plates are extracted using Optical Character Recognition (OCR) techniques and matched with the existing official registry of Land Transportation Office (LTO)records. Any plate numbers that are unregistered, tampered with, or do not conform to standard formats are flagged as illegal.

This technology-driven approach enhances the capability of local authorities to conduct efficient, accurate, and real-time monitoring of vehicles entering and moving within Dumangas. Automating vehicle plate recognition and verification to minimize human error, reduce inspection times, and promote road safety and law compliance. The system provides real-time notifications and reports for quick decision-making and rapid response, ensuring safer roads, regulated vehicle operations, and improved public order and security.

Keywords: *SECURE-SCAN, License Plate, Illegal VEHICLE PLATES, Optical Character Recognition, Security*

I. INTRODUCTION

The Municipality of Dumangas, a rapidly developing town in Iloilo, is experiencing a steady increase in vehicular traffic, bringing new challenges in road safety and law enforcement. One of the growing concerns is the prevalence of illegal vehicle plates, including expired, tampered, mismatched, and unregistered plates, which compromise public safety and hinder effective traffic management. Relying solely on manual inspection methods at checkpoints has proven inefficient, time-consuming, and vulnerable to human error, especially with the increasing volume of vehicles

passing through Dumangas' roads and highways.

To address this issue, this study introduces Secure-Scan, an automated License Plate Recognition (LPR) system designed to detect illegal vehicle plates using advanced artificial intelligence (AI) and optical character recognition (OCR) technologies. Secure Scan incorporates YOLOv8, a state-of-the-art deep learning model, for real-time license plate detection, coupled with Tesseract OCR for accurate text extraction. The system uses an ESP32-CAM module to capture vehicle images, processes them with OpenCV, and compares the recognized plates against a local SQLite database of registered vehicles.

By automating plate verification, Secure-Scan aims to enhance traffic law enforcement in Dumangas, reducing dependence on manual checks, minimizing errors, and ensuring faster, more accurate detection of illegal vehicle plates, contributing to safer and more orderly roadways.

II. METHODOLOGY

The conceptual framework of the study presented in Figure 1.

Figure 1 illustrates the operational flow of Secure-Scan: License Plate Recognition for Detection of Illegal Vehicle Plates. The framework is divided into three major components: input, process, and output, with system evaluation guided by the McCall Software Quality Model.

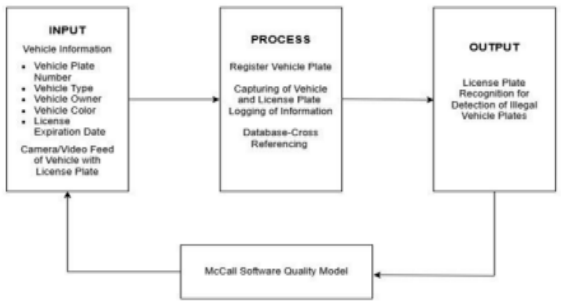


Figure 1. *Conceptual Framework of the Secure Scan: License Plate Recognition for Detection of Illegal Vehicle Plates*

The input stage involves gathering essential vehicle information, which includes the vehicle plate number, vehicle type, vehicle owner, vehicle color, and license expiration date. In addition, a live camera or video feed capturing the image of the vehicle and its license plate is also collected through the ESP32-CAM module. These data inputs are necessary for accurate recognition and verification of vehicle plate legitimacy.

The process component is responsible for handling and analyzing the input data. This involves registering vehicle plate records into the database, capturing real-time images of vehicles and their plates, logging the relevant information, and performing database cross-referencing. Through artificial intelligence using YOLOv8 for plate detection and Tesseract OCR for text extraction, the system verifies if the detected plate is registered, expired, mismatched, or unregistered by comparing it against a local SQLite database.

Finally, the output generates the recognition result, identifying illegal vehicle plates and providing detailed reports for local law enforcement. The system's performance is continuously evaluated using the McCall Software Quality Model, focusing on correctness, reliability, efficiency, integrity, and usability. This ensures that Secure-Scan remains reliable, efficient, and effective in supporting the traffic law enforcement system of the Municipality of Dumangas

This study adopts a developmental research design aimed at designing, developing, and evaluating the Secure-Scan system, an AI-powered License Plate Recognition (LPR) system for the detection of illegal vehicle plates. The research systematically explores how artificial intelligence and optical character recognition (OCR) technologies can enhance law enforcement operations and road safety within the Municipality of Dumangas.

A purposive sampling technique is employed to deliberately select respondents who possess relevant expertise and experience in license plate recognition, traffic law enforcement, and information technology. This ensures that feedback and system evaluations are guided by knowledgeable individuals who can provide critical, experience-based insights during system assessments.

The target respondents include ten (10) random vehicle owners, two (2) officers from the Dumangas Traffic Management Group (DTMG) specializing in traffic violation enforcement, and four (4) IT experts with backgrounds in computer vision and machine learning. These IT experts play a vital role in assessing the technical performance of the system through controlled test environments and real-world pilot testing conducted at Iloilo State University of Fisheries Science and Technology – Dumangas Campus.

This combined approach ensures that both practical and technical perspectives are integrated into the development process, resulting in a reliable, efficient, and user friendly system for illegal vehicle plate detection.

System Development Methodology

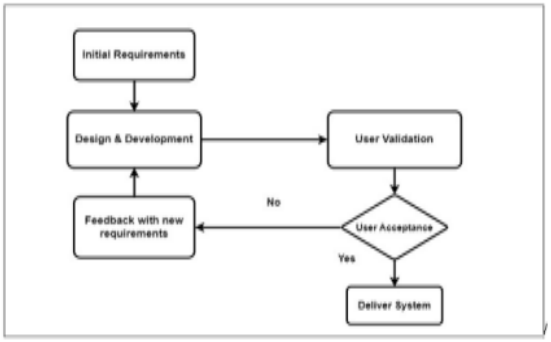


Figure 2. *Life Cycle Processes of Evolutionary Prototyping Methodology*

The diagram illustrates a system development lifecycle that aligns closely with the design and implementation process followed in the development of Secure-Scan. The process begins with identifying the Initial Requirements, where the study gathered data and defined the essential features of the system — such as real-time license plate detection, vehicle information logging, and illegal plate recognition for the Municipality of Dumangas.

Following this, the system enters the Design & Development stage, where the actual Secure-Scan prototype was built using YOLOv8 for license plate detection, Tesseract OCR for text extraction, and Python with a Flask-based interface. The system was then subjected to User Validation, involving trial runs and testing in controlled environments like ISUFST-Dumangas Campus, with feedback gathered from law enforcement personnel, LTO representatives, and potential system users.

During User Acceptance, if the system failed to meet user expectations or encountered operational issues,

it returned to the Feedback with New Requirements stage. Here, improvements were made based on suggestions, system errors, and new requirements before another round of validation. Once accepted, the system proceeded to the Deliver System stage, where the validated and approved version of Secure-Scan was made ready for deployment and possible scaling.

This iterative development cycle ensured that Secure-Scan was responsive, reliable, and met the practical needs of its intended users.

Deployment Diagram

The diagram illustrates the system architecture of the Secure-Scan license plate recognition system. At the core of the setup is the ESP32-CAM module, which serves as the primary video capturing device. This camera, equipped with Wi-Fi capability, is connected to a PC or laptop through a USB interface, enabling both power supply and data transmission. Once the videos are captured, they are processed by the connected computing device, which runs the Secure-Scan software responsible for detecting and extracting license plate information. The system then performs a real-time comparison of the detected license plate data against entries stored in a connected SQL-based database. Additionally, the diagram shows Internet connectivity, indicating the potential for remote access or cloud-based database synchronization for extended functionalities such as centralized monitoring, plate verification, or remote updates. This structured deployment ensures efficient data processing, real-time detection, and secure data management in alignment with the goals of the Secure-Scan system.

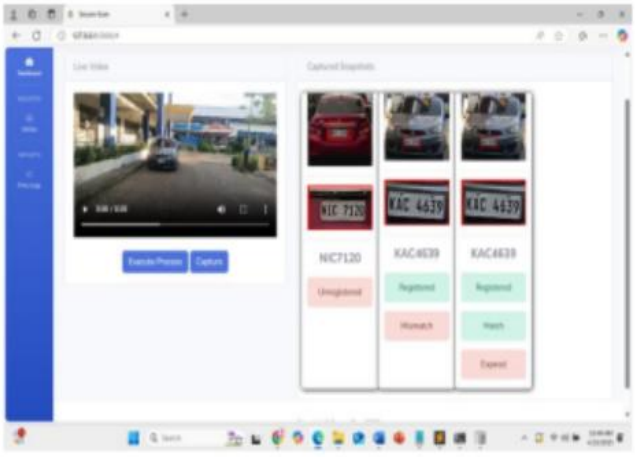
Figure 2 – The system architecture of the Secure-Scan license plate recognition system.

III. RESULTS AND DISCUSSION

The development and pilot testing of Secure-Scan: License Plate Recognition for Detection of Illegal Vehicle Plates revealed several important findings that demonstrate the system's potential to improve traffic law enforcement in the Municipality of Dumangas. The system showcased high detection accuracy by utilizing YOLOv8 for real-time license plate recognition and Tesseract OCR for precise text extraction. During its pilot testing at Iloilo State University of Fisheries Science and Technology – Dumangas Campus (ISUFST-DC), the system accurately identified both registered and illegal vehicle plates in controlled environments, proving its technical reliability. Additionally, Secure-Scan effectively performed cross-referencing of detected plates with a local SQLite database containing records of registered vehicles. It successfully flagged illegal entries such as expired, mismatched, or unregistered plates and automatically generated detailed reports to assist law enforcement authorities.

User feedback from law enforcement officers, traffic regulators, and IT experts validated the system's user-friendly interface, operational efficiency, and practical application in roadside enforcement. The Flask-based web interface made system access and monitoring highly convenient. Moreover, based on the evaluation using McCall's Software Quality Model, the system obtained impressive scores in correctness, reliability, efficiency, integrity, and usability, confirming its readiness for operational use. Despite its success in controlled testing, users recommended improvements, particularly in handling varying lighting conditions, high-traffic scenarios, and in the integration of the system with national vehicle databases to enable a more comprehensive and reliable deployment. These findings affirm Secure-Scan's value while identifying future directions for enhancement and wider implementation.

Prototype



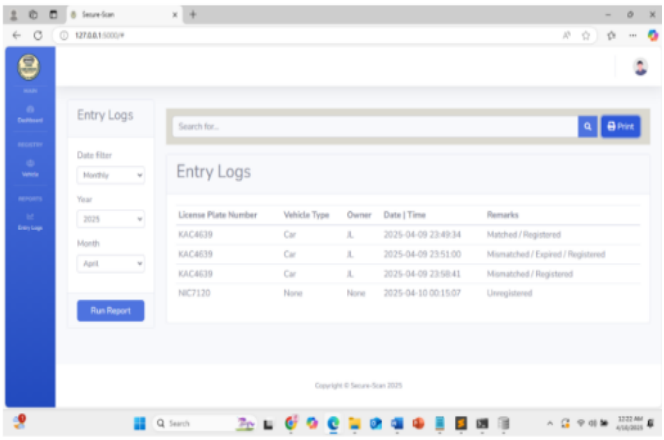


Table 1 shows the result of the mean average taken as a whole in terms of Product Operations.

Product Operations Characteristics	As A Whole	
	Mean	Description
Correctness	4.51	VE
Reliability	4.28	VE
Efficiency	4.63	VE
Integrity	4.69	VE
Usability	4.57	VE
Average Mean	4.53	VE

Table 2. The result of the mean average taken as a whole in terms of Product Revisions.

Product Revisions Characteristics	As A Whole	
	Mean	Description
Maintainability	4.39	VE
Testability	4.43	VE
Flexibility	4.35	VE
Average Mean	4.39	VE

Table 2 presents the overall results of the mean scores for Product Revisions Characteristics, which include Maintainability, Testability, and Flexibility of the Secure-Scan system. The data shows that Testability received the highest mean of 4.43, followed by Maintainability at 4.39, and Flexibility at 4.35. The average mean of 4.39 indicates a Very Effective (VE) rating for the system's product revision qualities. This suggests that the system is easy to maintain, can be tested efficiently, and adapts well to modifications and improvements. These results reflect the system's reliability and readiness for future updates, ensuring it remains operational and effective under evolving requirements and conditions.

Table 3 presents the mean scores for Product Transition Characteristics of the Secure-Scan system. Interoperability received the highest rating of 4.54, followed by Reusability at 4.25, and Portability at 4.17. With an average mean of 4.31, the system is

rated Very Effective (VE), indicating strong adaptability, reusability, and seamless integration with other systems, supporting broader deployment possibilities.

Table 3. The result of the mean average taken as a whole in terms of Product Transition.

Product Transition Characteristics	As A Whole	
	Mean	Description
Portability	4.17	E
Reusability	4.25	VE
Interoperability	4.54	VE
Average Mean	4.31	VE

CONCLUSIONS

The Secure-Scan: License Plate Recognition for Detection of Illegal Vehicle Plates system was successfully designed, developed, and evaluated, proving its capability in addressing the pressing issue of illegal and unregistered vehicle plates within the Municipality of Dumangas. Utilizing advanced AI-powered detection through YOLOv8 and Tesseract OCR, the system automates license plate identification and cross-references detected plates with a local database, effectively flagging expired, mismatched, or unregistered entries. This significantly reduces the reliance on manual checking, which is prone to delays and human errors.

Based on the evaluation using McCall's Software Quality Model, Secure-Scan achieved a "Very Effective" (VE) rating across Product Operation, Product Revision, and Product Transition categories, particularly excelling in Integrity, Efficiency, and Usability. Pilot testing at

ISUFST – Dumangas Campus validated its operational accuracy and user acceptance in controlled environments. Despite these strengths, limitations such as challenges in poor lighting, adverse weather, and high-speed traffic situations were identified, suggesting opportunities for further refinement.

The modular, scalable design of Secure-Scan positions it as a valuable prototype for future deployment in broader traffic management applications, with strong potential to enhance public safety, operational efficiency, and law enforcement capability within Dumangas and beyond.

RECOMMENDATONS

Based on the findings of this study, several recommendations are proposed to further improve the effectiveness, usability, and long-term viability of the Secure-Scan: License Plate Recognition for Detection of Illegal Vehicle Plates system. It is highly recommended to implement continuous system improvements by establishing regular feedback mechanisms from system users such as security personnel, Dumangas Traffic Management Group (DTMG) officers, and administrators. Their inputs will be essential in refining the system's usability, accuracy, and performance in varied operational environments.

Additionally, enhancing integration with existing surveillance infrastructures, law enforcement databases, and local vehicle registries, particularly with agencies like the Land Transportation Office (LTO) and insurance providers, will improve data accuracy and verification speed. Comprehensive user training programs should also be conducted to familiarize users with system features, promote efficient operation, and reduce resistance in transitioning from manual to automated processes. It is equally important to establish sustainable funding plans and collaborative partnerships with government offices and private organizations to support the long-term maintenance and development of the system.

Furthermore, future researchers are encouraged to explore solutions for the system's limitations in low-light, adverse weather, and high-speed traffic conditions. These initiatives will ensure that Secure-Scan remains relevant, reliable, and capable of significantly enhancing local traffic management and security operations.

REFERENCES

Amon, M. C. E., Brillantes, A. K. M., Billones, C. D., Billones, R. K. C., Jose, J. A. C., Sybingco, E., Dadios, E. J. P., Fillone, A., Gan Lim, L., & Bandala, A. A. (2019). Philippine license plate character recognition using Faster R-CNN with InceptionV2. In Proceedings of the 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM). IEEE. Retrieved from https://ieeexplore.ieee.org/document/9072753

GRobotronics. (n.d.). Camera module based on ESP32 with ESP32-CAM-MB adapter. Retrieved from https://grobotronics.com/camera-module-based-on-esp32-with esp32-cam-mb-adapter.html?sl=en#:~:text=Description,facial%20recognition

Microsoft. (n.d.). OCR - Optical Character Recognition - Azure AI services. Retrieved from https://learn.microsoft.com/en-us/azure/ai-services/computer-vision/overview-ocr

NYU Libraries. (n.d.). Tesseract OCR software tutorial. NYU Libraries Research Guides. Retrieved from https://guides.nyu.edu/tesseract#:~:text=Welcome,done%20through%20the%20terminal%20application

an, S., Liu, J., & Chen, D. (2022). Research on license plate detection and recognition system based on YOLOv7 and LPRNet. Academic Journal of Science and Technology, 4(2), 62–68. Retrieved from https://www.researchgate.net/publication/367054373_Research_on_License_Plate_Detection_and_Recognition_System_based_on_YOLOv7_and_LPRNet

acaldo, J. M., Wee, T. C., Pheng, L. W., Ancog, D. G., & Macalisang, H. A. R. C. (2021). Utilizing synthetically-generated license plate automatic detection and recognition of motor vehicle plates in Philippines. In Proceedings of the International Conference on Digital Transformation and Applications (ICDXA) (pp. 204–208). Tunku Abdul Rahman University College. Retrieved from https://www.researchgate.net/publication/356493380_UTILIZING_SYNTHETICA

LLY GENERATED_LICENSE_PLATE_AUTOMATIC_DETECTION_AND_RECOGNITION_OF_MOTOR_VEHICLE_PLATES_IN_PHILIPPINES

Pelco. (n.d.). License Plate Recognition: What is ALPR & LPR Technology? Retrieved from https://www.pelco.com/blog/license-plate recognition#:~:text=Automatic%20license%20plate%20recognition%20(ALPR)%2C%20also%20known%20as%20automatic,to%20the%20technology%20slightly %20diffe