

# Campus Car Theft Prevention Technologies: A Comprehensive Review of Automated License Plate Recognition and Rider Identification Systems

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**Abstract**— The rise in car theft on campuses across Nigeria has become an increasing concern, emphasizing the need for effective and technologically advanced preventive measures. This study provides a comprehensive review of car theft prevention technologies, with a focus on automated license plate recognition (ALPR) and rider identification systems. ALPR technology captures and identifies vehicle license plates in real-time, while rider identification systems, including facial recognition, help verify the identity of vehicle operators. This study explores the effectiveness, challenges, and ethical implications of these technologies in campus environments, thereby highlighting the potential role of these systems in enhancing campus security and identifying best practices for implementation. By synthesizing existing literature and case studies, this study offers insights into the feasibility and limitations of ALPR and rider identification integration, providing a foundation for further research and practical application in academic institutions.

**Keywords**—campus security, car theft prevention, ALPR, rider identification

## I. INTRODUCTION

In recent years, car theft and vehicle-related crimes have emerged as a significant challenge for university campuses, both globally and within Nigeria. Institutions are reporting alarming increases in these incidents, with students and staff frequently targeted. These crimes cause financial losses and undermine the essential sense of safety in academic institutions, for instance, Ohio's annual security reports, revealed a dramatic surge in car thefts from 2 to 65 within a year [1]. This trend is reflected in Nigerian campuses, where car theft has increasingly become prevalent. These incidents highlight a growing vulnerability in campus security, worsened by broader trends in crime.

In recent past, the following are some reported incidents of car thefts in educational institutions in Nigeria:

1. **Usman Danfodiyo University, Sokoto (UDUS):** A staff member's vehicle was stolen, raising concerns about campus security [2].
2. **University of Nigeria, Nsukka (UNN):** Thirty staff members were interrogated by the CID over theft incidents at the Enugu campus [3].
3. **Ekiti State University (EKSU):** Students have reported frequent car thefts, highlighting inadequacies in security measures [4].
4. **University of Lagos (UNILAG):** Vehicle vandalization and thefts are on the rise, with several individuals apprehended in recent years [5].
5. **University of Maiduguri:** A final-year student was arrested for stealing multiple vehicles, underscoring the severity of the problem [6].
6. **Nnamdi Azikiwe University (UNIZIK):** Dr. Fabian Osita tragically lost his life in a carjacking incident while resisting an attempted vehicle theft [7].
7. **University of Uyo (UNIUYO):** A security breach led to the theft of two vehicles, prompting the reintroduction of vehicle tally systems [8].

Despite efforts by universities to improve campus security through increased patrols, boom gates and vehicle tally system, the increasing prevalence of car theft underscores the limitations of traditional measures. Rising incidents on campuses along with numerous unreported cases, highlight a significant gap in existing security frameworks. Current solutions are often reactive rather than preventive, emphasizing an urgent need for innovative solutions.

Advanced technologies, particularly automated license plate recognition (ALPR) and rider identification systems, offer new possibilities for monitoring vehicles and enhancing campus safety. ALPR systems can automatically capture and analyze vehicle license plates, while rider identification technologies, like facial recognition, allow for verification of vehicle

operators. Together, these systems hold potential for a robust, automated solution to car theft on campuses.

This research therefore aims to bridge these gaps by evaluating the potential of ALPR and rider identification technologies as proactive tools to combat car theft on Nigerian university campuses. It focuses on assessing these technologies as preventive measures. It also explores the limitation and ethical considerations associated with their implementations. Aiming to propose effective strategies to mitigate the problem.

## II. LITERATURE REVIEW

Recent reports indicate a significant increase in vehicle thefts and break-ins on university campuses across Nigeria, raising concerns among students and university authorities, and prompting the implementation of various strategies to enhance campus security.

Campus security has historically relied on physical and manual approaches to prevent unauthorized access and deter vehicle related crimes. Physical barriers such as boom gates, while effective in restricting unauthorized vehicles, are often manually operated and vulnerable to being bypassed. Vehicle tally systems, which involve issuing physical tokens or receipts to vehicle owners upon entry, provide a simple mechanism to verify vehicle ownership at exit but are labor-intensive and prone to errors if tokens are lost or tampered with. Manual vehicle inspections conducted by security personnel offer an additional layer of verification by checking driver identification, vehicle registration, and vehicle contents; however, they are time-consuming, prone to human error, and can cause delays during peak hours. Similarly, regular security patrols of campus grounds and parking lots rely heavily on human vigilance and timely reporting. While they contribute to a visible security presence, these patrols often fail to prevent incidents like car theft in real time. Collectively, these traditional approaches, though foundational, reveal significant limitations in addressing the growing sophistication of vehicle theft on campuses.

To address these limitations of these traditional approaches, advanced technologies like Automated License Plate Recognition (ALPR) system have emerged as promising solutions. ALPR is a system that automatically recognizes, detect, extract and processes image or video stream when a vehicle comes into view, it then extracts and outputs the license plate content, typically in text format. These systems utilize a camera to capture vehicle images [9]. ALPR systems leverage computer vision, image processing and machine learning techniques to perform these tasks.

The operation of the ALPR system involves several stages. First, a camera captures images or videos of vehicles. Depending on the application, the camera may operate in color, black and white, or infrared to accommodate different lighting and environmental conditions. The system then detects the vehicle's license plate region within the captured image using algorithms such as edge detection, morphological operations, or deep learning models for object detection. Once the license plate region is isolated, the system separates individual characters using techniques like connected component analysis or

horizontal and vertical projection profiles. Optical Character Recognition (OCR) or machine learning-based models then convert these characters into text. The recognized license plate text is stored or transmitted for further analysis, such as retrieving additional information about the vehicle, including its make, model, color, or distinguishing characteristics.

ALPR systems have successfully been implemented in various domains. In urban area, they are used to enforce traffic laws, monitor road usage and manage congestion. An example is the London's Congestion Charge system which relies on ALPR to track vehicles entering designated zones and bill drivers automatically.

In smart parking lot solutions, ALPR systems automate entry and exit processes by recognizing vehicle license plates and associating them with user accounts or tickets, as seen in Schiphol Airport in the Netherlands.

Law enforcement agencies also leverage the ALPR technology to help identify stolen vehicles or vehicles involved in criminal activities. The Los Angeles Police Department for example, uses ALPR-equipped patrol cars to scan thousands of license plates daily to compare them against a database of wanted cars. ALPR is used in electronic toll collection systems, such as those implemented in the New York State Thruway, this has eliminated the need for physical toll booths and reduced traffic delays and operational costs.

Facial recognition systems have gained prominence as a cutting-edge solution in modern security frameworks. By capturing and analyzing unique facial features, these systems can accurately identify individuals in real time. They are widely implemented in various sectors, including airports, government buildings, and corporate facilities, where they streamline access control and enhance security. These systems rely on advanced algorithms that analyze and compare facial patterns from digital images or video footage against a database of stored facial profiles. The integration of artificial intelligence (AI) and machine learning has significantly improved the accuracy and speed of facial recognition, making it a valuable tool for enhancing security measures across various domains.

In the context of campus security, facial recognition can complement ALPR by providing an additional layer of identification for individuals associated with vehicles. This combination of technologies enhances the ability to track unauthorized access, prevent vehicle-related crimes, and improve the overall safety of campus environments.

## III. METHODOLOGY

### A. Research Design

This study conducts a comprehensive analysis of existing literature to evaluate the effectiveness of ALPR and rider identification systems in campus security frameworks. The descriptive approach was used in the collection and analysis of existing data to understand the effectiveness, privacy concerns, and feasibility of implementing ALPR and rider identification systems in preventing car theft on university campuses.

## B. Data Collection

Data for the study was collected from secondary sources, including:

**Academic Journals:** Peer-reviewed studies on ALPR systems, facial recognition technologies, and their applications in security contexts.

**Case Studies:** Documented implementations of ALPR and rider identification technologies in various sectors, including law enforcement agencies and smart city environments.

**Reports:** Reports from government and institutions, Publications by security technology firms and surveillance organizations detailing the effect of these technologies to reduce crime.

## C. Analysis Framework

The analysis will be conducted using a comparative framework that evaluates the following dimensions:

- Detection Rate:** The frequency at which stolen or unauthorized vehicles are identified using these technologies.
- Accuracy:** The precision of the systems in correctly identifying vehicles and riders.
- Implementation Challenges:** Concerns related to cost, infrastructure, and public acceptance.

## D. Limitations

This study relies on secondary data and existing case studies, which may not fully capture the contextual challenges specific to Nigerian universities. Future research could include primary data collection, such as pilot implementations and interviews, to provide a more comprehensive analysis.

# IV. DISCUSSION

## A. Effectiveness of ALPR in different Settings

ALPR systems is employed for multiple purposes, and have demonstrated significant success in settings such as law enforcement agencies, smart cities, university campuses and toll management. In law enforcement, ALPR enhances traffic-safety by detecting drivers with revoked, suspended, or restricted licenses, enforcing speed limits, and identifying vehicles that illegally pass stopped school buses [10]. A 2020 survey conducted by the American Bureau of Justice Statistics found that 65% of local police departments utilized ALPR [11]. Furthermore, The International Association of Chiefs of Police (IACP) reported that police vehicles equipped with ALPR technology exhibited 140% greater ability to detect stolen cars compared to those without. [12]. ALPR has also been instrumental in solving crimes on University campuses, as demonstrated by the police department of the University of Illinois[13].

In Smart cities, ALPR systems play a vital role in obtaining and analyzing timely statistical data about vehicles, providing insights into daily, weekly, monthly and yearly traffic patterns. This enables the authorities to monitor and control traffic conditions more effectively, thereby improving overall city management. [14].

Similarly, ALPR has revolutionized toll collection. For example, the E-Z Pass system, used across 17 north-eastern U.S states, relies on ALPR technology to enable seamless toll collection. This has enhanced enforcement efficiency and reduced reliance on physical toll booths, leading to improved efficiency and customer satisfaction [15].

Despite its broad applicability, ALPR faces challenges such as reduced accuracy in poor lighting and adverse weather conditions, which can lead to false positives or negatives, thus undermining the trust in the system..

## B. Effectiveness of Rider Identification Technologies in different settings

The Rider Identification System, leveraging technologies like facial recognition, offers a promising layer of security by verifying the identity of vehicle operators. Face recognition is mostly effective in places with a large population of unaware visitors, striking balance between security and privacy.[16].

Globally, facial recognition has been deployed extensively for public safety, customs and border security. For example, China has extensively deployed facial recognition technology for public safety and surveillance. Cameras integrated with facial recognition are used to identify suspects in crowds, enforce jaywalking fines, and monitor public spaces, as demonstrated by Henan province's surveillance initiative [17]. Similarly, major airports across the United States have implemented the facial recognition systems for customs and border security, expediting security checks and boarding processes.

In Nigeria, facial recognition has been adopted in key sectors. The Federal Government has implemented such systems in airports to strengthen security and streamline passenger identification.[18]. Financial institutions use facial biometrics to secure mobile banking platforms. This provides seamless and secure authentication, safeguarding against unauthorized access and fraud. Additionally, the Independent and National Electoral Commission (INEC) leverages the technology for enhanced voter verification [19]. While effective, facial recognition systems face challenges like demographic biases and significant privacy concerns, particularly in diverse populations..

## C. Case Studies on Integrating ALPR with Rider Recognition System

The integration of ALPR and facial recognition has shown considerable promise in enhancing security, during the Dubai World Expo 2020, advanced access control systems were implemented, integrating ALPR and facial recognition technologies. These systems were designed to monitor vehicle movement within the expo's territory and verifying occupants, significantly improving overall security [20]. Similarly, Earlham Savings Bank in central Iowa, United States implemented an integrated security solution combining ALPR cameras with IBM's facial recognition technology, thus enhancing the bank's ability to identify and respond to potential security threats [21]. Research by [22] explores a model that combines face recognition and number plate recognition to ensure vehicle safety and facilitate real-time tracking of

criminals and stolen vehicles, emphasizing their efficiency in surveillance.

TABLE I. COMPARATIVE ANALYSIS

	Comparative Analysis: ALPR vs. Facial Recognition vs. combined ALPR and Rider Identification Systems		
	ALPR Only	Facial Recognition only	Combined ALPR and Rider Identification
Effectiveness	Effective for vehicle identification; limited to license plate verification	Effective for verifying individuals but cannot identify cars	Enhanced security through simultaneous vehicle and rider verification
Cost	Lower cost of implementation than the facial recognition	Moderate cost. Dependent on hardware and software	High cost due to integration and hardware requirements
Privacy concerns	Moderate privacy concerns, limited to license plate data	Privacy concerns are high due to personal biometric data	High privacy concerns due to personal biometric data
Accuracy	Prone to errors in poor lighting or weather conditions	Prone to demographic biases and false matches.	Improved accuracy through multi-factor verification
Operational complexity	Relatively straightforward	Requires advanced software for recognizing individuals.	Complex, requiring system interoperability

#### D. Benefits and Challenges of Using These Two Technologies Together

Studies have highlighted the effectiveness of ALPR in combating theft by providing real-time detection and tracking capabilities. When combined with rider identification such as facial recognition, these systems create a robust, multi-layered approach to campus security. This combination can improve accuracy and operational efficiency by verifying both the vehicle and its operator, creating a system that is not only proactive but reliable.

Moreover, the combined system minimizes the reliance on manual checks, thereby minimizing human error and ensuring swift response to anomalies. This is particularly beneficial during high-traffic events, where the flow of cars and individuals is increased. Multi-factor verification addresses the inherent limitations in using ALPR or facial recognition as standalone systems. By corroborating vehicle and rider data, false positives associated with license plate errors are reduced. The visibility of such advanced security systems can also serve as a deterrent to potential car thieves. This dual verification system strengthens overall security.

However, the integration isn't without challenges. Technical Interoperability is a significant hurdle, ensuring seamless communication between ALPR and rider identification systems requires sophisticated software architecture and real-time data processing capabilities. These integrated systems generate large volumes of data, including high-resolution images and biometric profiles, necessitating robust infrastructure for efficient storage, retrieval, and analysis. Without proper data management, bottlenecks can compromise system performance and data integrity.

Additionally, there is the risk of misidentification, especially in crowded or poorly lit environments, which could lead to wrongful accusations or the failure to identify actual suspects. The technology can also be vulnerable to hacking or misuse, leading to unauthorized access or data breaches. Finally, the deployment of dual systems requires considerable investment in infrastructure, such as high-resolution cameras, advanced servers, and robust network connectivity. Additionally, regular maintenance and system upgrades contribute to ongoing costs.

#### A. Privacy Concerns and Data Security Issues

The adoption of facial recognition technology raises significant ethical concerns, particularly around privacy and data security. While effective for security, Facial recognition raises alarms about unauthorized surveillance and potential misuse of personal data. Critics argue that widespread surveillance may lead to misuse or unauthorized access to sensitive personal data, infringing on individual rights.

To mitigate these risks, institutions must adopt strict data protection measures, such as encryption, access controls, and secure data storage systems. Transparency in data collection and usage is vital, alongside obtaining informed consent from individuals. Regulatory frameworks like the Nigeria Data Protection Regulation (NDPR) emphasize the importance of adhering to principles of transparency, accountability, and consent. Compliance with these regulations not only safeguards personal data but also fosters public trust in the deployment of such technologies.

## V. CONCLUSION

### A. Key insights from the Review

In this paper, we reviewed the potential of ALPR and rider identification in addressing the pressing issue of vehicle theft on university campuses. The findings highlight that ALPR systems have proven effective in real-time detection and tracking, significantly reducing unauthorized vehicle access and aiding in theft recovery. Rider identification technologies, particularly facial recognition, complement ALPR by verifying the identity of vehicle operators, providing a dual layer of security. When combined, these systems create a robust framework for campus security, enhancing operational efficiency and reducing reliance on manual checks. However, challenges such as technical interoperability, privacy concerns, and substantial implementation costs must be carefully addressed to ensure their success.

## B. Implications for Campus Security

The deployment of ALPR and rider identification technologies holds significant implications for campus security. Their integration can:

**Enhance Theft Prevention:** Multi-factor verification ensures that both vehicles and operators are authorized, reducing the likelihood of theft or unauthorized access.

**Improve Real-Time Response:** Automated alerts enable swift intervention by security personnel, minimizing the impact of security breaches.

**Streamline Operations:** The automation of vehicle and rider verification reduces the burden on manual security processes, allowing personnel to focus on high-priority tasks.

Institutions must balance these benefits with ethical and operational considerations. Addressing privacy concerns, ensuring data protection, and fostering community trust are critical to successful adoption.

## VI. RECOMMENDATIONS

To maximize the potential of ALPR and rider identification technologies while addressing their challenges, the following recommendations are proposed:

**Phased Implementation.** Where universities adopt these technologies incrementally, starting with standalone ALPR systems before integrating rider identification technologies. This approach allows for testing and refinement of each component. Institutions must also invest in robust infrastructure, including high-resolution cameras, advanced servers, and reliable network connectivity, to support these systems effectively. Privacy and Data Protection Measures must be put in place to safeguard personal and biometric data. Compliance to Nigeria's Data Protection Regulation (NDPR) should also be prioritized.

**Community Engagement** should also be prioritized. Universities should actively involve students and staff in discussions about the deployment of these technologies. Transparency and education can help address concerns and build trust. Lastly, cost management should be considered. Collaborative funding models, such as partnerships with technology providers or government agencies, can help offset the high implementation costs.

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