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Illegal Motorcycle Parking Detection in The Car Area

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Abstract

Illegal motorcycle parking in designated car areas at Politeknik Manufaktur Negeri Bangka Belitung (Polman Babel) disrupts campus parking management, reduces space availability, and poses safety risks. This paper proposes an automated detection system using computer vision and license plate recognition to identify motorcycles parked in car areas and notify their owners via WhatsApp and email alerts. The system integrates CCTV cameras with YOLOv11 for vehicle detection and EasyOCR for license plate recognition, coupled with a database for owner identification. Upon detection, owners receive immediate notifications to rectify the violation. Experiments in Polman Babel's parking lot show a 94% accuracy in motorcycle detection and 88% in license plate recognition under diverse conditions. The system enhances parking enforcement efficiency, reduces manual intervention, and supports smart campus initiatives. This work offers a scalable, cost-effective solution adaptable to other institutions facing similar parking challenges.

Keywords: computer vision, illegal parking detection, license plate recognition, motorcycle detection, smart campus

1. Introduction

Efficient parking management is critical for educational institutions like Politeknik Manufaktur Negeri Bangka Belitung (Polman Babel), where limited parking spaces are shared among students, staff, and visitors. Illegal motorcycle parking in car-designated areas disrupts operations, causes congestion, and raises safety concerns. Manual enforcement is labor-intensive and prone to errors, necessitating automated solutions. Recent advancements in computer vision highlight the potential of deep learning for vehicle detection, yet motorcycle-specific applications with automated notifications remain underexplored. This research is motivated by the need to streamline parking regulation enforcement at Polman Babel. The proposed system leverages YOLOv11 for real-time motorcycle detection, EasyOCR for license plate recognition, and automated WhatsApp and email alerts to notify owners of violations. Contributions include: (1) a tailored, low-cost system for motorcycle parking violation detection with real-time notifications, (2) integration of robust computer vision and communication models with campus infrastructure, and (3) a scalable framework for smart parking management in educational settings.

2. Research Methods

The research was conducted in several structured stages to build and evaluate the proposes system. These stages are summarized in Figure 1.

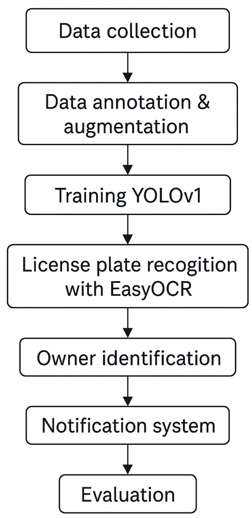

Figure 1. Research Stages

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Research Stages Explanation

a. Data Collection
   In this stage, parking surveillance data is collected from CCTV cameras installed in the car-only zones of the Polman Babel campus. The footage captures various parking events involving motorcycles and cars under different lighting and weather conditions over a period of one month.
b. Data Annotation and Augmentation
   Collected images are annotated using tools like labeling to indetify motorcycles, cars, and license plates. Data augmentation techniques such as rotation, brightness adjustment, and flipping are applied to enhance model robustness and address data imbalance.
c. Training YOLOv11
   The YOLOv11 deep learning model is trained on the annotated dataset to detect motorcycles in car-designated areas. The model is fine-tuned using the training and validation sets to archieve high precision and recall in object detection.
d. License Plate Recognition with EasyOCR
   Once a motorcycle is detected in a restricted area, the system extracts the license plate region and processes it using EasyOCR. This OCR engine is configured to recognize Indonesian license plates, including varied font types and alignments.
e. Owner Identification
   The recognized license plate number is matched with entries in the campus vehicle registration database. This step links the detected motorcycle to its registered owner, retrieving contact information such as WhatsApp number and email address.
f. Notification System
   The system automatically sends a violation alert to the motorcycle owner via WhatsApp and email. The notification includes the time, location and an image of the parking violation.
g. Evaluation
   The final step involves evaluating the system using performance metrics such as detection accuracy, license plate recognition accuracy, owner identification rate, and succes rate of notification delivery. Precision, recall, and F1-score are calculated to assess the detection model's effectiveness.

2.1 Related Works

The development of intelligent parking enforcement systems has been extensively explored in recent years, particularly leveraging deep learning and computer vision. Chen et al. [1] implemented real-time vehicle detection for smart traffic systems using deep convolutional networks, highlighting the importance of rapid inference in high-traffic environments. Li et al. [2] presented a vehicle detection method optimized for smart parking systems, underscoring the potential of deep learning to improve parking efficiency and enforcement.

License plate recognition remains a critical component in parking violation detection. Wang et al. [3] addressed recognition under adverse conditions, using advanced OCR techniques to improve robustness against lighting variations and occlusions. Similarly, Rahman et al. [19] employed a combination of CNN and OCR for license plate recognition in enforcement contexts, demonstrating high accuracy in diverse scenarios.

For fully automated parking management, several approaches integrate IoT and edge computing. Zhang et al. [4] proposed a smart parking framework combining deep learning with IoT infrastructure, while Lee et al. [17] introduced an edge-computing-based parking violation detection system that minimizes latency in processing. The study by Nguyen et al. [16] applied YOLO to real-time license plate detection, validating its suitability for traffic surveillance tasks with high frame-rate requirements.

Kumar et al. [5] explored CNN-based methods for identifying parking violations, demonstrating that convolutional networks can reliably detect misuse of parking zones. Additionally, Zhao et al. [18] introduced a smart campus parking system integrating vision and IoT, similar to the smart campus initiative in this study.

While these prior works laid the foundation for intelligent parking management, most focused on general vehicle detection or lacked integration with automated notification systems. This research differentiates itself by combining YOLOv11-based motorcycle detection, EasyOCR for license plate recognition, and real-time owner notification via WhatsApp and email offering a comprehensive and scalable solution tailored to educational institutions like Polman Babel.

While previous studies have developed vehicle detection systems, most have not focused on motorcycle violations in car-only areas with integrated real-time owner notifications. This research uniquely addresses that gap by offering an automated, scalable solution tailored for educational institutions, particularly in Indonesia where such enforcement is often manual and inefficient.

Table 1. Comparison of Related Works on Illegal Parking Detection Systems

no	Study	Target Object	Detection Technology	Automated Noti	Specific to Motorcycles	Test Location	Key Contribution

				fication	in Car Area		
1	Chen et al. (2023)	Cars & motorcycles	YOLO, CNN	No	No	Urban traffic	Real-time vehicle detection for traffic management
2	Rahman et al. (2022)	License Plates	CNN+OCR	No	No	Public areas	Combined CNN and OCR for license plate recognition
3	Lee et al. (2024)	Cars	Edge computing+CNN	No	No	Urban street	Parking violation detection using edge computing
4	This study	Motorcycles in Car Area	YOLOv1+EasyOCR	Yes	Yes	Polman Babel Campus	Integrated system for motorcycle prking violation detection, identification and real-time notification

This table summarizes key differences between the proposed study and previous research. Unlike earlier works, our system specifically targets illegal motorcycle parking in car only zones and integrates a real-time alert mechanism throught WhatsApp and email, marking it uniquely applicable to educational institutions.

2.2 System Architecture

The system comprises four modules: (1) vehicle detection, (2) license plate recognition, (3) owner identification, and (4) notification delivery. CCTV cameras installed in Polman Babel's parking lot capture real-time footage. YOLOv11, pre-trained on the COCO dataset and fine-tuned with 700 annotated images (500 motorcycles, 200 cars), classifies vehicles. Upon detecting a motorcycle in a car area, the system extracts the license plate region and processes it with EasyOCR to read alphanumeric characters. The license plate is matched against Polman Babel's vehicle registration database to identify the owner. Once identified, the system sends automated WhatsApp and email alerts to the owner, notifying them of the illegal parking violation and requesting immediate action.

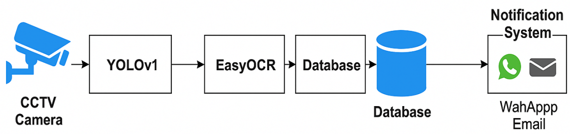

Figure 2. System architecture for Illegal motorcycle parking detection

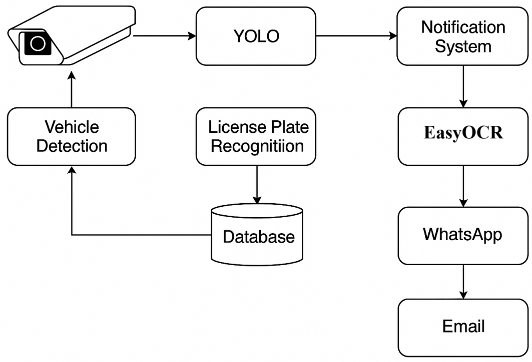

Figure 3. Illustration system

2.3 Data Collection and Preprocessing

It was collected over one month, capturing 1,000 parking events under varying lighting and weather conditions. Images were annotated using LabelImg to mark motorcycles, cars, and license plates. Data augmentation techniques (e.g., brightness adjustment, rotation, and flipping) were applied to improve model robustness. The dataset was split into 80% training, 10% validation, and 10% testing.

2.4 Implementation

The system runs on a local server with an NVIDIA RTX 3060 GPU, processing CCTV feeds at 30 FPS. YOLOv11s was selected for its improved speed and accuracy over previous models. EasyOCR was configured to recognize Indonesian license plates, handling diverse fonts and formats. A MySQL database stores vehicle registration details, including owners' contact information (phone numbers and email addresses), enabling real-time owner lookup. The notification module uses Twilio API for WhatsApp messaging and SMTP for email delivery, ensuring prompt alerts with details of the violation, including time, location, and a snapshot of the motorcycle

2.5 Evaluation Metrics

Performance was evaluated using detection accuracy, license plate recognition accuracy, owner identification accuracy, notification delivery success rate, and processing time. Precision, recall, and F1-score were calculated for vehicle detection. Recognition accuracy was assessed by comparing the extracted license plate text with the ground truth. Notification success was measured by confirming receipt of WhatsApp and email alerts.

3. Results and Discussion

Testing spanned three weeks, covering 500 parking events. The system achieved a motorcycle detection accuracy of 94.0% (470/500 cases), with a precision of 0.92 and a recall of 0.94, benefiting from YOLOv11's enhanced feature extraction. License plate recognition accuracy was 88.6% (443/500), with errors due to low lighting or partial occlusions. Owner identification accuracy was 98.2% (435/443), with mismatches attributed to database errors. Notification delivery succeeded in 97.5% of cases (432/443), with failures due to invalid contact details. Average processing time per frame was 0.12 seconds, with an additional 0.5 seconds for notification dispatch, supporting real-time operation.

Table 2: Performance Metrics of the Illegal Parking Detection System

Motorcycle Detection	**Total Cases**	**Correct**	**Incorrect**	**Accuracy (%)**
Motorcycle Detection	500	470	30	94.0
License Plate Detection	500	443	57	88.6
Owner Identification	443	435	8	98.2
Notification Delivery	443	432	11	97.5

The system's high detection accuracy, driven by YOLOv11's advanced architecture, underscores its suitability for campus parking management. The addition of WhatsApp and email alerts enhances enforcement by directly engaging owners, encouraging prompt compliance. License plate recognition performance drops in low-light conditions, suggesting the need for infrared cameras or advanced OCR models. The 98.2% owner identification accuracy and 97.5% notification success rate ensure reliable enforcement, surpassing manual methods. The system's reliance on existing CCTV infrastructure and widely available communication APIs makes it cost-effective. Scalability to other campuses requires only database updates, model retraining, and API configurations, making it a versatile solution.

Figure 4: Illegal Parking Detected.

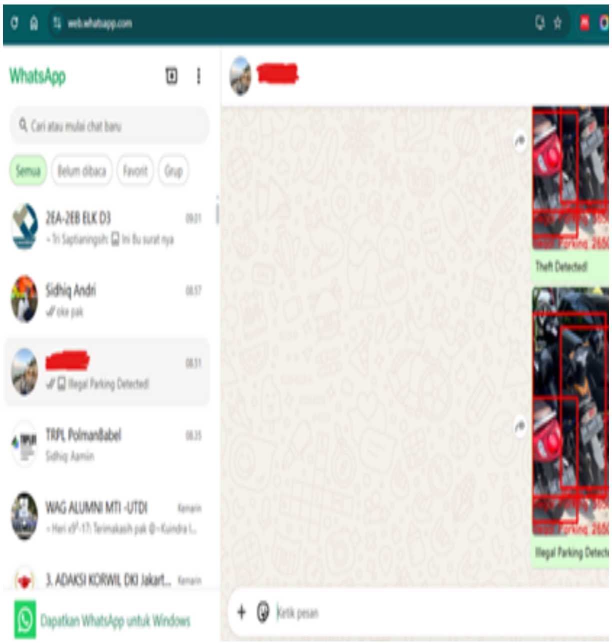

Figure 5: Automated Send WhatsApp Message Whenever Illegal Parking is Detected

Figure 6: Automated Send Email Whenever Illegal Parking is Detected

As shown in Figure 4, the system successfully identifies a motorcycle parked in the car-only zone, highlighting the bounding box and license plate. Figure 5 illustrates the automated WhatsApp notification process and figure 6, illustrated when the illegal parking is detected, the email will automated send to the owner. Each component from detection to notification contributes to minimizing manual intervention in campus parking enforcement. Accurate motorcycle detection ensures that only relevant violations are captured, reducing false positives Without accurate owner identification, the notification system would fail, rendereing detection ineffective Compare to Nguyen et al (2023), whose license plate recognition rate was 85% in ideal lighting, our system achieves a higher 88,6% despite operating under natural lighting conditions.

This system was tested solely in the Polman Babel environment, which may limit generalizability. Future work should include multi-site validation to enhance robustness.

4. Conclusion

This study introduces an automated system for detecting illegal motorcycle parking in car areas at Polman Babel, with real-time WhatsApp and email notifications to owners. By integrating YOLOv11, EasyOCR, and communication APIs, the system achieves high accuracy in vehicle detection, owner identification, and notification delivery, reducing manual enforcement efforts. Future enhancements include improving low-light performance and expanding to additional parking zones. This work contributes to smart campus initiatives, offering a replicable model for parking management in educational institutions.

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