Evaluation of YOLOv8 Algorithm for Vehicle License Plate Detection System in UNY Integrated Parking Lot

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Abstract

The YOLOv8 algorithm for the license plate detection system of vehicles entering the integrated parking lot of Universitas Negeri Yogyakarta (UNY) needs to be evaluated because license plate detection is crucial in integrated parking management to improve the security and efficiency of parking lot usage. YOLOv8, as a deep learning-based object detection algorithm, was chosen to improve the accuracy and speed of detection. This research combines the YOLOv8 approach with a dataset specifically designed for the context of UNY parking lots. The testing process was conducted using the required hardware and software to ensure the algorithm's ability to adapt to the real environment. In addition, the performance of YOLOv8 in detecting vehicle license plates under different vehicle license plate conditions, such as black plates or white plates, was also evaluated. The results show that YOLOv8 is able to provide adequate vehicle license plate detection results. This research contributes to give development result of a vehicle license plate detection system for parking management by utilizing the latest object detection technology, as well as providing an overview of the challenges and solutions for implementation of this algorithm in the specific context of UNY parking lots.

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INTRODUCTION

In the era of rapidly evolving information technology, understanding the expression of human emotions is becoming increasingly important, especially in the context of developing communication systems and artificial intelligence. Motorized vehicles have become an integral part of everyday life, providing convenience in mobility and connectivity. Due to the rapid growth in the number of vehicles, parking management has become increasingly crucial to ensure efficiency and orderliness. Yogyakarta State University (UNY), as a dynamic and progressive educational institution, is no exception to this challenge. Operational sustainability and security of the integrated parking area are top priorities in supporting campus activities. One proactive measure to improve parking management is through the implementation of a vehicle license plate detection system. This system not only facilitates more effective monitoring of incoming and outgoing vehicles but also provides invaluable information in parking planning and management. To improve the reliability of this system, this research will focus on the evaluation of the YOLOv8 (You Only Look Once version 8) object detection model on a custom dataset collected from the integrated parking lot environment at UNY. YOLOv8 is a sophisticated object detection model that takes into account the multiscale nature of objects, using three layers of scale detection to accommodate objects with different scales [1,2].

Vehicle license plate detection is not a simple task as it involves factors such as changes in light conditions, variations in viewing angle, and variations in the shape of license plates. While license plate recognition technology has been widely used in real life, this technology is more often used in fixed scenarios and environments, and the accuracy and robustness of the existing recognition technology can hardly meet the needs of real life[1]. Existing recognition technology can hardly meet the needs to realize the application under complex and real-time conditions to show that the method proposed in the previous paper by Hengliang Shi in 2023 is to use the effectiveness of the Yolov5 algorithm of license plate recognition, but only a degree of recognition and recognition has not yet reached the stage of reading the license number. Therefore, the selection of an advanced object detection model such as YOLOv8 is important to ensure optimal accuracy and responsiveness. This study aims to investigate the effectiveness of YOLOv8 in detecting vehicle licenses by number plates in UNY's integrated parking lot conditions that may involve vehicles with various types and characteristics. By combining advanced object detection technology with specialized datasets, this research seeks to improve the accuracy, speed, and reliability of the vehicle license plate detection system to support efficient parking management within UNY. Through this research, it is hoped that a meaningful contribution can be made in the development of parking management technology, not only for the needs of UNY but also as a broader contribution in the context of modern and sustainable city parking management.

According to [3,2], with the rapid growth of Artificial Intelligence (AI), vehicle detection has become a major research topic, mainly due to its potential applications in various challenging tasks. These tasks include traffic management, autonomous driving, surveillance systems, and other related fields. Vehicle detection systems can be used to enhance safety, optimize traffic flow, and contribute to the development of intelligent transportation systems. Through this research, it is hoped that a model can be created that serves as the foundation for the development of applications in different domains, such as smart traffic control, parking management, and advanced driver assistance systems. This has the potential to positively impact the field of transportation by creating technology that is more efficient and responsive to the demands of modern society. In summary, the research on vehicle detection systems aims to leverage AI to create innovative solutions that improve traffic management, enhance safety, and contribute to the evolution of intelligent transportation systems.

Therefore, in recent years, various applications [4, 5, 6, 7, 8] using object detection YOLO have been developed. In addition, interest in video processing techniques [9, 10] to improve intelligence at the network edge is also increasing. Many applications using YOLO perform object detection from images captured in real time using IP (network) cameras. However, in the case of YOLO, its performance varies greatly depending on the hardware running the YOLO core for object detection services. As a result, YOLO's real-time processing is highly dependent on hardware specifications. Thus, the interest in improving the real-time processing capability of YOLO has greatly increased in recent years, and various studies are being conducted [11, 12, 13, 14] to solve the real-time object detection problem of YOLO. Most of the research on improving YOLO real-time processing has proposed various methods to reduce the size and complexity of the neural network inside YOLO. However, using these methods is undesirable in terms of YOLO's user convenience because all of YOLO's internal models must be modified, and additional verification of the object detection performance itself is required to apply new techniques in an application such as framing.

An Adaptive Frame Control technique is proposed to improve real-time object detection processing while maintaining the object detection performance of the YOLO system. The proposed model enables consistent object detection services for various YOLO input sources and can solve real-time processing problems that may occur in the Real-Time Streaming Protocol (RTSP) used with YOLO object detection applications when the video input sources of the application are IP cameras. The

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proposed AFC is designed and added to the existing YOLO, and enables real-time object detection with the deadlines required by various applications, by optimizing the input frames from various sources and providing adaptively controlled frames to the YOLO.

METHODS

Block Diagram Detection of Indonesian Vehicle License Plates

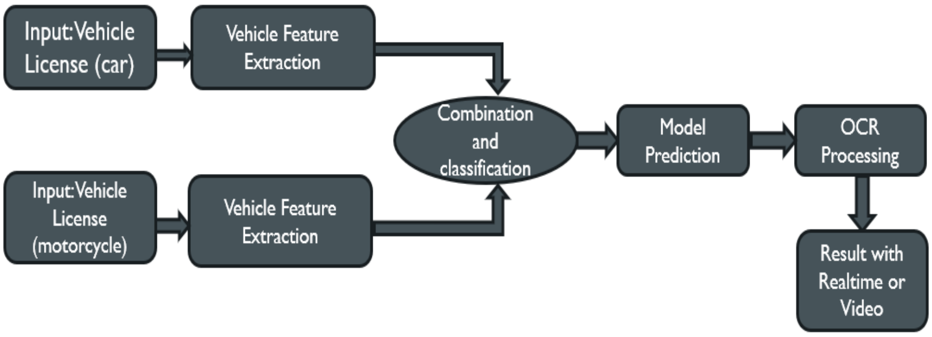

Figure 1. Block Diagram Detection of Indonesian Vehicle License Plates

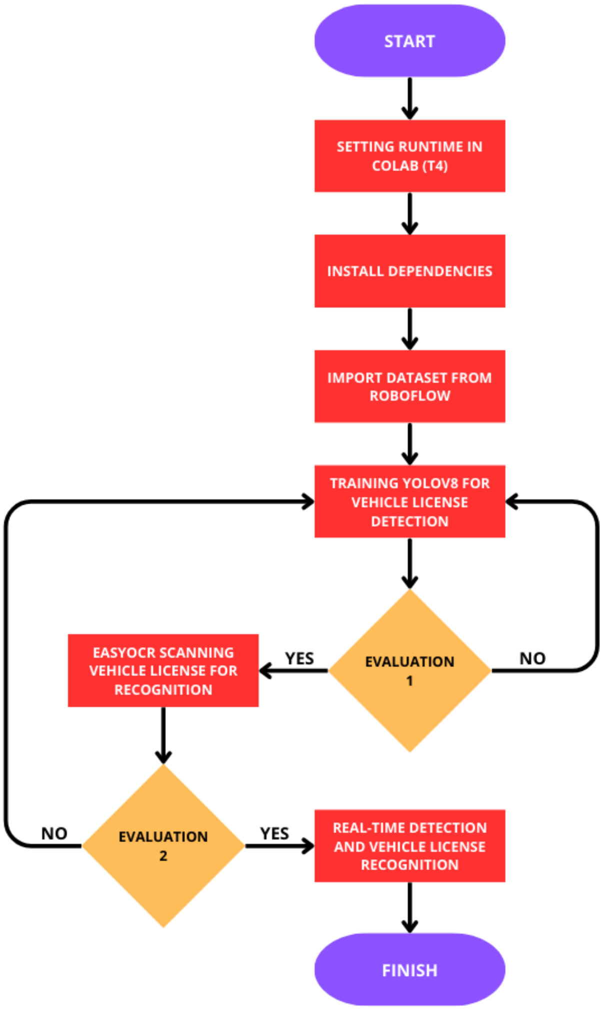

Figure 2. Research Flowchart System

Figure 1 explains the diagram related to the working system of the number plate detection (TNBK). This research is designed by combining vehicle license datasets that are inputted into inputs, after which each input is extracted using CNN. The extracted datasets are then combined so that the classification stage can be carried out. The classification results get predictions about license plate detection. License or license plate that is successfully predicted and identified, then the detection image is processed through the OCR (Optical Character Recognition) technique or in Indonesian, namely Optical Character Recognition. OCR is a technology used to recognize text or characters from scanned images or documents, and it is used for object detection. Easy-OCR is used for character recognition [15, 16]. The main purpose of OCR is to convert the text printed on the license plate into text that can be read clearly by cameras and supervisors. The prediction results issued by the EasyOCR system as OCR processing will be displayed directly in real-time on the video or webcam camera. In the flowchart, when running the TNBK detection program, one must first prepare the platform that will be used to process the YOLO program code. In this study, Google Colab was used as a platform to compile the system. After making preparations on google colab, the next step is to install dependencies which are to find packages from the program so that it can be compiled into a detection system. Installation of dependencies includes such as tensorflow, sklearn, etc. Then for the process as shown in Figure 2.

Dataset

Dataset is taken from RoboFlow, which is a platform that provides end-to-end solutions for processing and management of datasets in the context of object detection, including vehicle datasets with license plates [17, 18]. The platform makes it easy for researchers and developers to access, manage, and structure datasets quickly and efficiently. With an intuitive interface, users can easily browse datasets, review images, and validate license plate labels. RoboFlow also provides various tools to improve dataset quality, such as data augmentation to train models with greater variety. Using datasets from RoboFlow can provide a solid foundation for training and testing license plate detection algorithms. This allows your research to take advantage of already well-managed resources and accelerate the development stage of object detection models in vehicles with license plates. RoboFlow also provides advanced features such as integration with popular machine learning tools, including TensorFlow and PyTorch. This makes it easy for researchers to implement object detection models, such as YOLOv8 mentioned in your research, using datasets imported from RoboFlow. In addition to YOLO, RoboFlow also supports common dataset formats such as COCO, and Pascal VOC, thus facilitating integration with various machine learning frameworks [17]. The process of data exploration and pre-processing becomes more efficient thanks to the user-friendly interface and various analysis tools provided by the platform.

Figure 3. Roboflow Dataset

RoboFlow also provides advanced features such as integration with popular machine learning tools, including TensorFlow and PyTorch. This makes it easy for researchers to implement object detection models, such as YOLOv8 mentioned in your research, using datasets imported from

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RoboFlow. In addition to YOLO, RoboFlow also supports common dataset formats such as COCO, and Pascal VOC, thus facilitating integration with various machine learning frameworks [17, 20]. The process of data exploration and pre-processing becomes more efficient thanks to the user-friendly interface and various analysis tools provided by the platform. Utilization of the RoboFlow dataset in TNKB license plate detection research, it can be ensured that the dataset used has gone through a careful management process, providing a solid basis for the development and evaluation of object detection models with a focus on vehicle license plates in the UNY integrated parking environment.

EasyOCR Scanner

EasyOCR is an optical character recognition (OCR) system that draws inspiration and contributions from recent works in academia and open source projects. Incorporating the latest concepts in image processing and context understanding, EasyOCR creates a turnkey OCR product with state-of-the-art performance. The platform leverages the latest research that has been conducted in the field of natural language processing and character recognition, combining innovative ideas from academic projects with contributions from the open-source community. With this approach, EasyOCR can provide an effective and adaptive OCR solution for a wide range of needs, be it for text documents, images, or situations that require character processing.

EasyOCR integration can make it easy to detect and extract text from various sources, including documents, images, and even videos. Support for advanced performance guarantees reliable and accurate results in OCR applications. In addition, the ability to use off-the-shelf products can accelerate the development of systems that require character recognition technology. EasyOCR's innovative approach helps overcome the challenges of character recognition under various conditions, including variations in font, size, and orientation of text. The product not only utilizes advancements in the field of OCR but also takes into account aspects such as transfer learning and fine-tuning to improve performance on specific tasks.

EasyOCR's advantage lies in its ability to provide a robust character recognition solution without the need for complex programming or customization. By utilizing a ready-to-use product that has been developed through synthesizing the latest research, EasyOCR provides a reliable solution that can be easily integrated in various applications, including vehicle license plate detection and recognition, document processing, and other OCR applications [19].

RESULT AND DISCUSSION

The dataset derived from RoboFlow and extracted features resulted in several vehicle classifications. From each classification, the results of the evaluation of the YOLOv8 algorithm in the context of vehicle license plate detection in the Integrated Parking Lot of Yogyakarta State University (UNY) are explored. The research steps detailed in the previous chapter lead us to an in-depth understanding of how YOLOv8 performs in capturing crucial information from the license plates of vehicles entering the parking area.

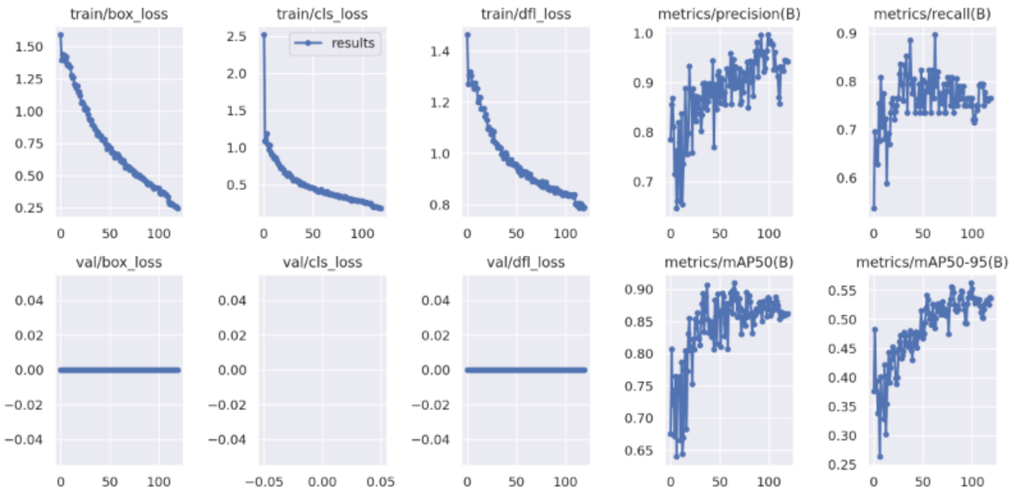

Figure 4. Training and Validation Loss of YOLOv8 Model

The analysis in Figure 4 discusses in detail the parameters used in the YOLOv8 algorithm, including the network configuration, training process, and other parameters that affect the detection results. We focus on precision, recall, and other performance evaluation metrics to provide a holistic view of the algorithm's ability to recognize license plates under various lighting conditions and vehicle variations. It can be seen that there is overfitting but not so significant, for the device used is cloud-based provided by Google on the Google Colab platform with exposure to specifications, namely using 16 GB RAM and 16 GB VRAM GPU (using Nvidia Tesla T4).

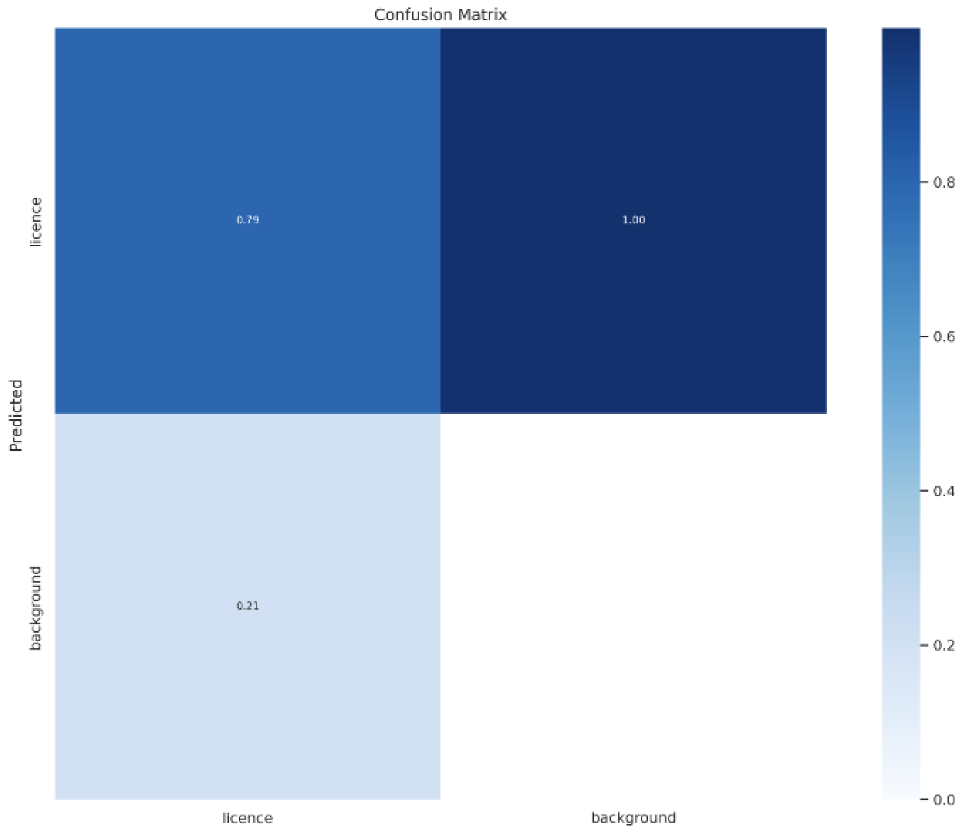

Figure 5. Confusion Matrix Result

Figure 5. visualizes the results of the confusion matrix between background and license predictions (TNKB). By examining each cell in the Confusion Matrix, we can identify predicted the licenses is of 0.79, and the miss of the background of the plate predicted 0.21.

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In discussing the evaluation results of the YOLOv8 Algorithm for vehicle license plate detection in the Integrated Parking Lot of Yogyakarta State University (UNY), we will not only focus on the general performance but will also detail the findings through Confusion Matrix analysis. Confusion Matrix provides a more detailed view of the accuracy and precision of the algorithm in classifying objects. The hierarchical confusion matrix concept describes the four fields of the confusion matrix in relation to the decisions made during prediction [21]. All necessary dataset preprocessing techniques have been accomplished by applying various tools available in open-source datasets such as Roboflow [22]. The Confusion Matrix is generated through testing with a carefully prepared dataset, covering various lighting conditions and vehicle variations on the RoboFlow dataset. The results of the Confusion Matrix analysis will be described, providing a deeper understanding of the extent to which the algorithm is able to correctly identify license plates in certain situations [15]. Through the application of the Confusion Matrix, we can identify areas where YOLOv8 is consistently successful, as well as situations where there may be detection errors. This step is crucial to evaluate the reliability of the algorithm in the context of UNY's integrated parking lot and provide more detailed directions for improvements or optimizations that may be needed in subsequent steps.

Figure 6. Result of Number Plate Detection System Reading without EasyOCR

Figure 7. Result of Number Plate Detection System Reading with EasyOCR

Figures 6 and 7 show the system reading results of the License Plate Detection. It can be seen that if the system is equipped with EasyOCR for inference from YOLOv8 model validation detection before, because we use YOLOv8 for OCR Recognition of number on license plate, so it can read the number plate until it mentions the contents of the number on the plate, but when reading is not equipped with EasyOCR inference, the system just only identify the plate, not the number of plates. EasyOCR is inference model from plate detection with YOLOv8 model validation and utilized for extracting characters from license plates. A dataset obtained from GitHub is employed for training and testing the proposed model [15, 23]. The accuracy and efficiency of the system, were evaluated against various environmental conditions, including different lighting and weather scenarios. The results show that system can already perform character recognition. For cases such as moving vehicles, the black license plate is also crucial, so its use in parking lot systems is still possible. This improvement in accuracy using inference library like EasyOCR is crucial for the application of smart parking systems at UNY, where accurate and reliable license plate recognition is paramount. In addition, the system's performance was compared with other OCR tools without plate detection to assess its relative effectiveness. The comparison showed that the system outperformed in terms of speed and accuracy, especially in real-time applications [24, 25].

CONCLUSION

In highlighting the positive contributions made by evaluation of the YOLOv8 algorithm in vehicle license plate detection in the Integrated Parking environment of Yogyakarta State University (UNY). The analysis of the results shows that YOLOv8 has great potential in improving parking security and management systems, making it an effective and efficient solution for the Yogyakarta State University campus environment. For the implementation steps also show that YOLOv8 is able to provide real-time detection system, an important factor to support the efficiency of parking management within UNY. This speed of response can reinforce necessary security and management actions quickly, improving user experience and optimizing parking space utilization.

While the YOLOv10 has been release on this year, YOLOv8 still showed high reliability, there are some aspects to consider for further development. For example, parameter optimization and configuration adjustments could be potential measures to improve detection accuracy under certain conditions of weather for vehicle license plate detection, like rainy days, foggy, etc. In addition, improvements to the hardware and software infrastructure like embedded system detection could support the performance of the algorithm in more complex scenarios on vehicle license plate detection directly. Overall, evaluation of the YOLOv8 algorithm in vehicle license plate detection in UNY's integrated parking lot made a positive and progressive contribution. The findings provide a solid foundation for further development, bringing the parking security and management system towards a better and sustainable solution.

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the successful Implementation and Evaluation of YOLOv8 Algorithm for Vehicle Number Plate Detection in UNY Integrated Parking Lot.

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