Journal of Computer Networks, Architecture and High Performance Computing
Volume 6, Number 3, July 2024
https://doi.org/10.47709/cnapc.v6i3.4377

Submitted : 23 July 2024
Accepted : 29 July 2024
Published : 31 July 2024

YOLO-Based Vehicle Detection: Literature Review

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ABSTRACT

This research aims to evaluate the implementation of the You Only Look Once (YOLO) algorithm and its variants in the context of vehicle detection in traffic management systems. The importance of implementing intelligent transportation systems (ITS) in increasing transportation efficiency and reducing traffic problems such as congestion and accidents. The methodology used involves a critical review of current literature utilizing the YOLO algorithm for vehicle detection, with a focus on improving the accuracy of detection models. The research results show that the YOLO algorithm and its variants, such as YOLOv4 and YOLOv8, show a significant increase in vehicle detection accuracy reaching 90% in various environmental conditions. However, weaknesses in detecting small objects and in extreme lighting conditions still need further attention. This study also reviews several improvement approaches proposed in the literature, including the use of image augmentation techniques and the integration of deep learning models to improve the performance of the YOLO algorithm. The implementation of the YOLO algorithm in vehicle detection in intelligent transportation systems has great potential in increasing the efficiency and accuracy of traffic monitoring. This research provides recommendations for further development so that the YOLO algorithm can be better adapted to various environmental conditions and different types of data.

Keywords : Vehicle Detection; YOLO; YOLO Series; ITS; YOLO Architecture

1. INTRODUCTION

ITS (Intelligent Transportation Systems) provides efficient services related to various modes of transportation and traffic management without requiring relevant knowledge, thus making better information available to different users (Debnath et al., 2014). In addition, ITS also plays an important role in transporting goods and people from one location to another via the road network (Schlingensiepen et al., 2015). Transport of goods and people varies depending on distance, weight, volume, type of load, and even local road infrastructure (Ho et al., 2019). However, the road transportation system has several serious problems such as congestion, accidents, and inadequate road infrastructure (Oyeyemi Olayode et al., 2023). The complexity of the problems of the road transportation system, monitoring traffic flow accurately and efficiently is becoming an increasingly greater challenge (Rajput et al., 2022).

Therefore, vehicular computing using computer vision-based approaches will provide highly accurate real-time vehicle analysis and small-scale solutions to this problem (Tsalikidis et al., 2024). Computer vision plays an important role in traffic monitoring systems. Researchers have proposed various new models and techniques to be applied to various problems such as vehicle counting (Contreras & Gamess, 2020), vehicle detection (J. Chen et al., 2023), traffic jam detection, and vehicle tracking. All of these are also very important applications in ITS services. Apart from that, data and information are much richer (Keerthi Kiran et al., 2021).

The application of computer vision with one-step detection techniques such as You Only Look Once (YOLO) has been one of the main choices in various previous studies in the last decade (Terven et al., 2023) and various models have been combined with this model as one of the best solutions in previous systems (Terven et al., 2023).The aim of this research focuses on the application of YOLO and its variants in vehicle detection, especially in traffic management, as well as the proposed improvements and applied methodology to increase the accuracy of the proposed model. To achieve this goal, this study critically evaluates the latest research and research results on vehicle detection using the various data sets used and the models to be proposed.

2. LITERATURE REVIEW

As one of the most representative networks, the YOLO architecture provides excellent performance in terms of

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speed and accuracy and has high potential in the field of intelligent transportation problems. Therefore, this research answers the question of whether YOLO and its variants are applicable in vehicle detection. Vehicle detection and classification is the most important and demanding task in intelligent traffic monitoring systems. Traditional methods require intensive computing and have limitations along with changes in the type of data collection. In recent years, several previous studies have shown important results related to this application, such as Mudawi Al Naif et al (Al Mudawi et al., 2023b) proposed a new approach for vehicle detection and classification through a series of photos air. In this research, the YOLOv8 algorithm was used to detect and localize vehicles in each image based on various feature extractions such as Scale Invariant Feature Transform (SIFT), Oriented FAST and Rotated BRIEF (ORB), and KAZE. The test results achieved an accuracy of 95.6% on the Vehicle Detection in Aerial Imagery (VEDAI) dataset and 94.6% on the Vehicle Aerial Imagery from Drones (VAID) dataset.

Mingle Xu et al (Xu et al., 2023) also discussed the current state and future direction of image enlargement, as well as three related topics: understanding image enlargement, new strategies for utilizing image enlargement, and image enhancement. Zarei, N et al (Zarei et al., 2023) proposed a differential segmentation based YOLO network (DS_YOLO) based on SAMG module to segment differential input images into two classes. vehicle class and background class. This research highlights the results of existing research, on the application of YOLO and its variants in vehicle detection, especially in traffic management, as well as the suggested improvements and proposed methodological improvements to improve the accuracy of the proposed model. Therefore, the results of this research can be used as a reference for the development of intelligent traffic monitoring systems in the future.

3. METHOD

The proposed research framework is illustrated in figure 1.

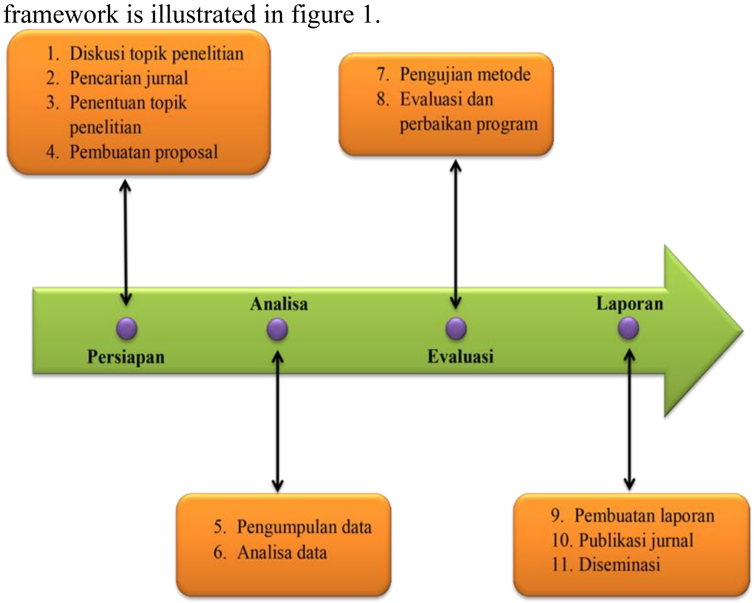

Fig.1 Research Framework

4. RESULT

In this section, the results of a review of several journals that are relevant to the topic to be discussed will be described. Some of the results of this research were collected from international journal sources indexed Q3, Q2, and Q1, such as MDPI, IEEE, Hindawi, Science Direct, and IJISAE. Detecting vehicles in a video stream is an object detection problem. The object detection problem can be approached as a classification or regression problem. The classification approach divides the image into several small parts and runs each part through a classifier to determine whether an object is in that part. Bounding boxes are assigned to sections with positive classification results. In the regression approach, the entire image is passed directly to a convolutional neural network, which generates one or more bounding boxes for the objects in the image. In recent decades, various algorithms used for object detection have

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been applied in vehicle detection with a variety of different data sources, such as SSD, EfficientNet, Faster RCNN, and YOLO.

YOLO (You Only Look Once) was released in 2016 by Joseph Redmon, Santosh Divala, Ross Girshick, and Ali Farhadi. This algorithm presents object detection as a regression problem and can be performed in real time with high accuracy using an approach that passes through a connected neural network. The system partitions the input image into an S×S grid, and each grid cell predicts a bounding box, confidence in that box, and class probability. The prediction is encoded as a tensor S×S×(B∗5 +C) (Redmon et al., 2016). The application of YOLO as an object detection algorithm plays an important role in various fields. In addition, this algorithm has high accuracy and its development continues to increase from the first version to the tenth version. These results show that YOLO has attracted significant interest from many researchers, and a comprehensive review of YOLO is very important.

Over the last decade, YOLO applications (Chung et al., 2023; Han et al., 2021; Lindenheim-Locher et al., 2023; G. Wang et al., 2023; Y. Wang et al., 2023) in various variations have been widely used for purposes in various fields, such as vehicle detection (Han et al., 2021). However, this algorithm still requires further development to achieve higher accuracy, including: (Tian et al., 2019) introduced YOLO-CA to improve YOLO's performance in car accident detection whose performance reached more than 90%. Nam Bu et al (Nam Bui et al., 2020) proposed a combination of YOLOv3 and deep sort as a comprehensive vehicle counting framework with Multi-Class Multi-Movement computing. Furthermore, Wang C et al (C. Wang et al., 2020) proposed a vision-based crash detection framework for mixed traffic flow environments by considering low visibility situations. The Retinex algorithm was introduced to improve image quality in low visibility conditions such as night, fog and rain. Meanwhile, Zhou L et al [Zhou et al., 2020] proposed Filter-DeblurGAN and VL-YOLO to carry out a deblurring mechanism.

MME-YOLO (Zhu et al., 2021) is a new model that improves the performance of YOLO in vehicle detection on the road. (Yang et al., 2023) introduced YOLO-BEV as a high-precision maritime small object detection system based on a ship-based UAV scenario. Research conducted by Wang L et al (Y. Wang et al., 2023) proposed a vehicle exterior object detection model based on the YOLOv4 model by improving the anchor frame grouping, loss function, and neck network in YOLO. Meanwhile, Vikruthi S et al (Vikruthi et al., 2023) proposed a faster and more accurate way to prioritize emergency vehicles based on YOLOv7 and GBM. Other new methods FA-YOLO (Du et al., 2021), UAV-YOLOv8 (G. Wang et al., 2023), YOLO-UAV (Ma et al., 2023), Eagle-YOLO (Liao et al., 2023), T-YOLO (Padilla Carrasco et al., 2023), MEB-YOLO (Song et al., 2023), GGT-YOLO (Y. Li et al., 2022), GCL-YOLO (Cao et al., 2023), and others (Pham et al., 2020; S & P, 2021; Tahir et al., 2024; Y. Wang et al., 2023; Zhou et al., 2020). In general, the improvements suggested by researchers tend to focus on specific issues that can be adapted to the needs and problems.

5. DISCUSSIONS

Improving the performance of YOLO in applications in various fields, small object detection applications using various data sources such as UAVs, CCTV cameras (Cao et al., 2023; Ji et al., 2023; X. Li et al., 2024; Pham et al., 2020; G. Wang et al., 2023; Yang et al., 2023) and various other problems is possible happens .video. Many researchers have applied various other approaches to improve YOLO performance, such as: optimizing YOLO performance because previous methods are ineffective and there are differences in traffic density that fluctuate throughout the day. As a result, vehicles often have to wait for long periods of time, even though traffic density is low or non-existent.

In addition, YOLO's weakness in detecting small objects in unmanned vehicles (UAVs) has attracted the attention of many researchers, for example compared the performance of YOLOv3 and YOLOv4. In the study of Sharma A et al (Biyik et al., 2023), detection of Yolov4-tiny was proposed. This makes computing more cost-effective, significantly reduces memory requirements, and enables applications deployed in embedded systems. On the other hand, the performance of YOLOv5 is improved in (Z. Chen et al., 2022; Zhang et al., 2022). YOLOv5 is the latest version of the YOLO series which is famous for its speed and accuracy. This version is highly customizable and easier to train than previous versions. For real-time applications such as traffic management, this algorithm is proven to be accurate and easy to implement (Al Mudawi et al., 2023a). However, vehicle detection with UAVs has several drawbacks, such as small targets consisting of car parts in parking lots. Due to severe limitations on the size of convolutional neural networks, the above algorithms are weak in improving the vehicle detection process on high-resolution images. The image resolution captured by the UAV is much higher than the image size allowed by the object detection model. In addition, previous methods suffer from iterative computational problems that reduce the consistency of detection and tracking

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6. CONCLUSION

From the results of descriptions from various previous studies, it can be seen that the application of YOLO has been proven to be accurate with high accuracy in various fields. Moreover, the development of this algorithm, over the last decade has proven its success in applications in various fields using different sources. However, some researchers proposed different improvements, which prove that directly applying YOLO on different data sets still needs to be adjusted. This has resulted in various other variants of this algorithm. Apart from that, the YOLO algorithm needs to undergo various improvements to increase the accuracy of the results depending on the problem, namely increasing performance in detecting small objects from cameras, videos or unmanned vehicles, detecting objects that change size or overlap with other objects in the video scene and other problems. Vehicle detection in extreme environmental conditions such as low lighting, strong lighting, bright light, rainy weather and night vision.

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Submitted : 23 July 2024
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Published : 31 July 2024

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Journal of Computer Networks, Architecture and High Performance Computing
Volume 6, Number 3, July 2024
https://doi.org/10.47709/cnapc.v6i3.4377

Submitted : 23 July 2024
Accepted : 29 July 2024
Published : 31 July 2024

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