Car Parking Space Detection Using YOLOv8

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Abstract: For many years, parking has been a major issue in many cities all around the world. Air pollution and traffic congestion can be decreased by providing information about available parking spaces. Thus, the purpose of this study is to use YOLOv8 algorithm to identify the quantity of cars and available spaces in parking lots. Videos were captured with a camera in different scenarios at UTA'45 Jakarta, and the dataset was prepared by extracting frames from these videos. There are no pre-labeled images in the dataset, so all of the images have been manually annotated. Multiple object detection has been accomplished by implementing YOLOv8 algorithm to detect cars and available spaces. This paper discusses two architectures: YOLOv8 and YOLOv5. The performance of various designs is assessed by comparing the precision, recall, and mAP values. YOLOv8 performs better than YOLOv5 when both performances are applied. In terms of mAP 0.5, mAP 0.5:0.95, and recall, the YOLOv8 model performs better than the YOLOv5 model; the differences in the values of each performance are 0.8%, 1.6%, and 1.2%. With a 0.5% difference in accuracy performance value, the YOLOv5 model outperforms the YOLOv8 model.

1 INTRODUCTION

Parking is a basic facility in every facility and infrastructure service provider such as shopping centers, ports, airports, etc. As time goes by the need for parking space tends to increase with the increase in visitors bringing private vehicles, especially cars. Adequate parking facilities are needed for the convenience of visitors, so parking managers provide spacious parking spaces even with multi-level parking patterns. This condition will become difficult if there are only a few remaining parking slots. This makes the driver have to search the parking lot to find a parking lot that is still available. (Sani & Ayyasy, 2022)

Object detection or commonly called object detection is a process used to determine the presence of certain objects in a digital image. The detection process can be carried out using various methods which basically read the features of all objects in the input image. The features of the object in the image will be compared with the features of the reference object or template and then compared and determining whether the detected object is the object you want to detect or not. (Rizkatama et al., 2021)

Artificial intelligence technology such as You Only Look Once (YOLO) has been applied and used in many different industries. This article presents a smart parking system using artificial intelligence. In complex urban environments where the number of vehicles continues to increase, vehicle drivers have time to find parking and traffic congestion increases during rush hours (Acharya et al., 2018). After entering the parking lot, it took time to find a parking space. To alleviate these problems, a camera-based Parking Guidance Information (PGI) system has been investigated. (Chen & Chang, 2011).

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2 METHODS

This research discusses about car parking detection using YOLOv8. The research was carried out by taking 5000 image of the parking space which were checked manually one by one and classified from morning to evening. This is because the parking space is only busy at that time.

2.1 Original YOLO Algorithm

YOLO was introduced to the computer vision community through a paper publication in 2016 with titled "You Only Look Once: Unified, Real-Time Object Detection." (Redmon et al., 2016). The paper reframed object detection, essentially presenting it as a one-shot regression problem, starting with image pixels and moving on to bounding boxes and class probabilities. The proposed approach, based on the concept of "unification", allows the simultaneous prediction of multiple bounding boxes and class probabilities, improving both speed and accuracy.

Since its founding in 2015 until this year (2023), the YOLO family has continued to grow at a rapid pace. Although the original author (Joseph Redmon) discontinued his research in the field of computer vision with YOLO-v3 (Vidyavani et al., 2019) , the effectiveness and potential of the main 'unified' concept has been expanded upon by several authors, with the newest addition to the YOLO family coming in the form of YOLO-v8. Figure 1 shows the evolution timeline of YOLO.

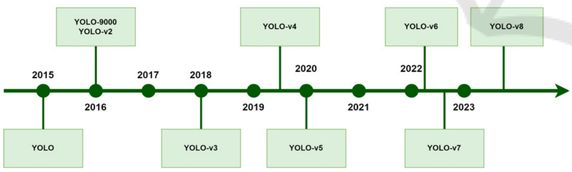

Figure 1: Timeline of YOLO.

2.2 YOLO v8

The newest of the YOLO family was confirmed in January 2023 with the release of YOLO-v8 (Jocher & Tune, 2023) by Ultralytics (YOLO-v5 was also released). Although the release of the paper is just around the corner and many features have yet to be added to the YOLO v8 repository, a first comparison between the newcomer and its predecessor shows the advantages of the new cutting-edge as his YOLO is shown.

Figure 2 shows that when comparing YOLO-v8 with YOLO-v5 and YOLOv6 trained at image resolution 640, all YOLO-v8 variants achieve better throughput with a similar number of parameters, demonstrating hardware-efficient architectural innovations. YOLO-v8 and YOLO-v5 are introduced by Ultralytics, YOLO-v5 offers superior real-time performance, and based on initial benchmark results published by Ultralytics, YOLO-v8 can focus on Constrained Edge. There are high expectations. Provides device provisioning with high inference speeds.

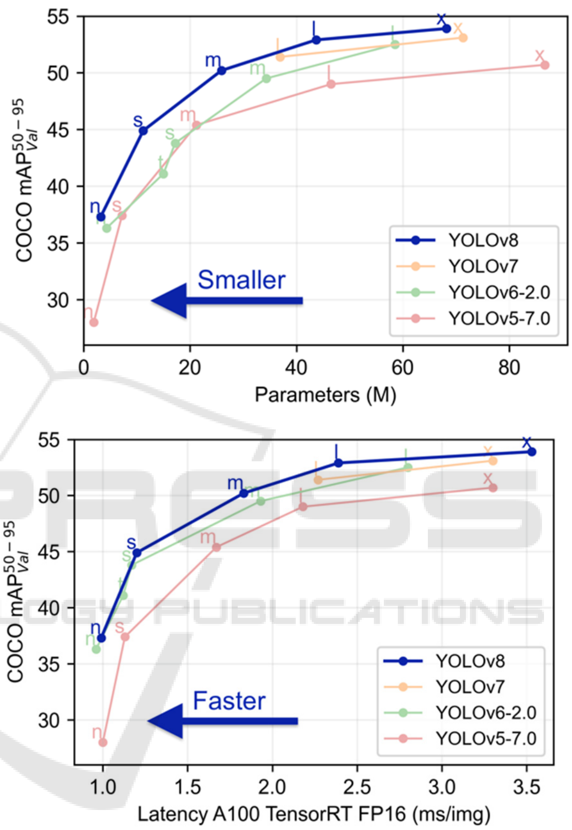

Figure 2: YOLO-v8 comparison with predecessors (Jocher & Tune, 2023).

The backbone part of YOLOv8 is fundamentally the same as that of YOLOv5, and the C3 module is supplanted by the C2f module based on the CSP thought. The C2f module learned from the ELAN thought in YOLOv7 and combined C3 and ELAN to create the C2f module (Wang et al., 2022).

In the neck part, the feature fusion method used in YOLOv8 is still PAN-FPN, which enhances the fusion and utilization of feature layer information at different scales. To assemble the neck module, the creator of YOLOv8 used two up-sampling modules and multiple her C2f modules, along with the final separated head structure. The idea of cutting off

YOLOx's head was used in her YOLOv8 for the last part of the neck. We achieved a new level of accuracy by combining confidence and regression boxes.

YOLOv8 supports all versions of YOLO and allows you to switch between different versions at will. It can also run on different hardware platforms (CPU-GPU), giving you great flexibility. The YOLOv8 network architecture diagram is shown in Figure 3. The CBS in Figure 3 consists of a convolution function, a batch normalization function, and a SiLu activation function.

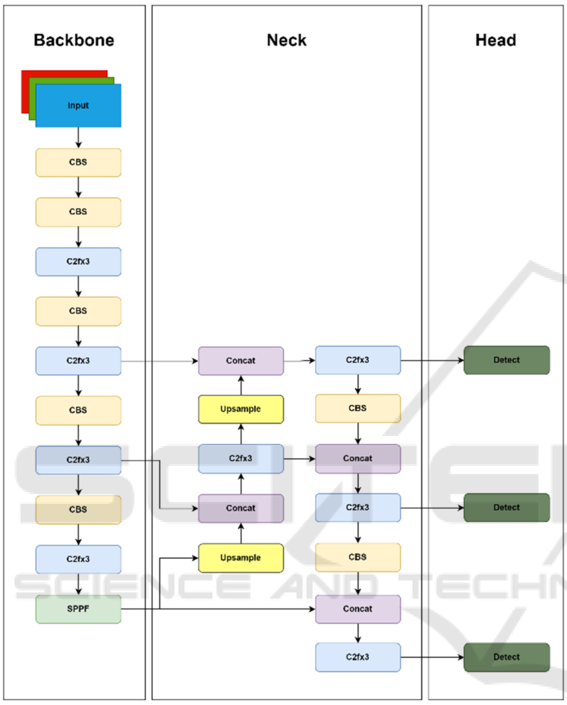

Figure 3: The network structure of YOLOv8.

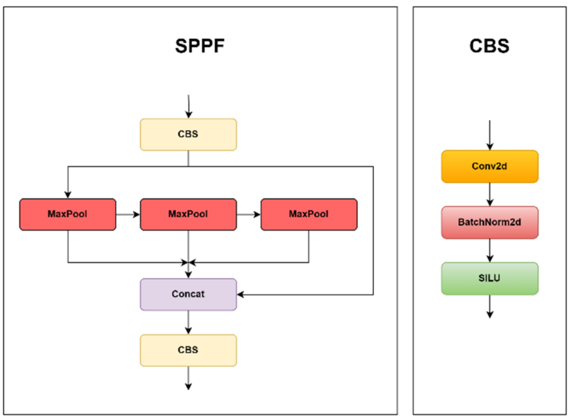

Figure 4: SPFF and CBS structure.

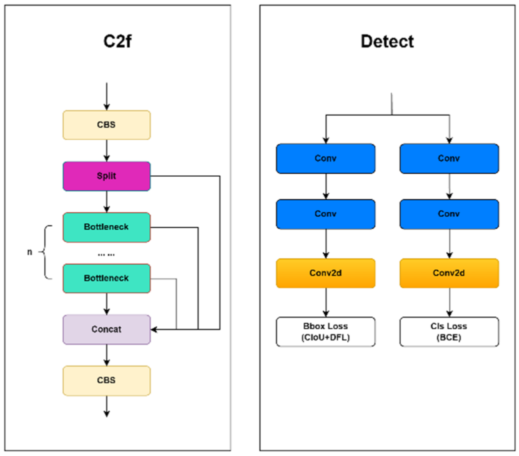

Figure 5: C2f and Detect structure.

2.3 Parking Lots Detection

YOLOv8 is the latest version of YOLO by Ultralytics. As a cutting-edge, state-of-the-art (SOTA) model, YOLOv8 builds on the success of previous versions, introducing new features and improvements for enhanced performance, flexibility, and efficiency. YOLOv8 supports a full range of vision AI tasks, including detection, segmentation, pose estimation, tracking, and classification as seen in Figure 3. This versatility allows users to leverage YOLOv8's capabilities across diverse applications and domains.

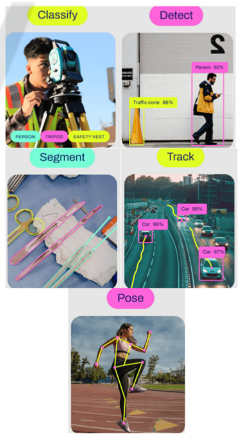

Figure 6: YOLOv8 Ultralytics performs.

YOLOv8 Detect, Segment and Pose models pre-trained on the COCO dataset are available, as well as YOLOv8 Classify models pre-trained on the ImageNet dataset. Track mode is available for all Detect, Segment and Pose models. All models can be seen in Table 1.

Table 1: Models on YOLOv8.

Model	size (pixels)	mAP^{val} 50-95	Speed CPU ONNX (ms)	Speed A100 TensorRT (ms)	Params (M)	FLOPS (B)
YOLOv8n	640	37.3	80.4	0.99	3.2	8.7
YOLOv8s	640	44.9	128.4	1.20	11.2	28.6
YOLOv8m	640	50.2	234.7	1.83	25.9	78.9
YOLOv8l	640	52.9	375.2	2.39	43.7	165.2
YOLOv8x	640	53.9	479.1	3.53	68.2	257.8

3 RESULTS AND DISCUSSION

To enhance each step, the YOLOv8s algorithm was tested and trained on the UTA'45 Jakarta Lot Parking dataset, and its results were compared with those of YOLOv5 to confirm that this approach could increase the precision of space availability and car targets detection. Lastly, in order to compare the detection outcomes of the suggested approach and the YOLOv5 algorithm in real scenes, we chose images of complicated sceneries in various scenarios.

It has been determined after numerous testing that the algorithm basically iterates 438 before starting to converge. We determined the following parameters based on the hardware available and several testing runs: batch size=16, epoch=2000.

3.1 Experimental Platform

Google Colab served as the online platform for the experiments in this work, and the system hardware included an NVIDIA T4 GPU and 16GB of RAM (software platform: torch-2.0.1+cu118, Google Colab).

3.2 Valuation Index

Evaluation metrics: Mean average precision (mAP), average precision (AP), precision (P), and recall (R). The formulas for P and R are as follows:

$$P = \frac{TP}{(TP + FP)} \tag{1}$$

$$R = \frac{TP}{(TP + FN)} \tag{2}$$

TP is the number of correctly predicted bounding boxes, FP is the number of incorrectly judged positive samples, and FN is the number of undetected targets.

Average Precision (AP) is the average accuracy of the model. Mean Average Precision (mAP) is the average value of the AP. K is the number of categories (Lou et al., 2023). The formulas for AP and mAP are as follows:

$$AP = \int_0^1 p(r)dr \tag{3}$$

$$mAP = \frac{1}{k}\sum_{i=1}^{k} AP_i \tag{4}$$

3.3 Experimental Result Analysis

We performed the training and inference procedure using the UTA'45 Jakarta Lot Parking dataset and compared it with YOLOv5s to validate the detection effect of the suggested approach on available space and cars in this research. Students studying electrical engineering at UTA'45 Jakarta, Indonesia, gathered the UTA'45 Jakarta Lot Parking dataset. The dataset was gathered from the sixth floor of the UTA'45 Jakarta building using a Logitech C270 HD Webcam. The camera captured a variety of situations and lighting conditions, resulting in a large number of parking spaces and cars in complex environments.

The assessment index for this experiment is mAP0.5, mAP0.5:0.9, which amply demonstrates the experiment's authenticity. Table 2 displays the test results.

Table 2: Algorithm comparison at each stage.

Detection Algorithm	Result				
	Epoch	mAP 0.5	mAP 0.5:0.95	P	R
YOLOv8s	371	0.955	0.828	0.953	0.924
YOLOv5s	1237	0.947	0.812	0.958	0.912

Table 2 demonstrated that the YOLOv8s algorithm has a certain improvement at each stage for the detection of available spaces and cars in complex scenarios. Furthermore, there is a 1% improvement in the mAP 0.5 and mAP 0.5:0.95, indicating significant room for development. It is demonstrable that the YOLOv8s in this experiment work quite well. The experimental findings demonstrated that the YOLOv8s outperforms the YOLOv5s in terms of performance.

4 CONCLUSION

In contrast to conventional approaches, this study suggests a camera sensor-based algorithm for detecting cars and available space for smart parking projects. It is known that the YOLOv5 and YOLOv8 models have successfully detected cars and available spaces in parking lot images based on the research findings that have been described. Variations exist in parking lot detecting performance metrics. For recall, mAP 0.5, and mAP 0.5:0.95, the YOLOv8 model performs better than the YOLOv5 model; the differences in the values of each performance are 0.8%, 1.6%, and 1.2%. With a 0.5% difference in accuracy performance value, the YOLOv5 model outperforms the YOLOv8 model.

We will keep researching camera sensors in-depth in the future in an effort to meet our target of being able to recognize objects in different parking lots more accurately than current detectors as soon as feasible.

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