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COMPARISON OF YOLOV12 AND YOLOV11 IN SAR IMAGE SHIP DETECTION

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Annotation: This study evaluates the performance of YOLOv12 in SAR image target detection compared to YOLOv11. Experimental results demonstrate that YOLOv12 outperforms YOLOv11 in detection accuracy (mAP50 and mAP50-95), small target detection, and complex background processing, exhibiting faster training convergence and stronger generalization ability. The study validates the advantages of YOLOv12 in SAR image target detection.

Keywords: SAR image; target detection, YOLOv12, performance comparison.

Introduction. Synthetic Aperture Radar (SAR) images play a crucial role in target detection tasks due to their all-weather and all-day imaging capabilities. However, SAR image characteristics such as speckle noise, complex textures, and small target distribution pose challenges to detection models. As the latest version of the YOLO series, YOLOv12 introduces the Area Attention module and Residual Efficient Layer Aggregation Network (R-ELAN), further enhancing global modeling capability and feature aggregation efficiency. This study aims to evaluate YOLOv12's performance in SAR image target detection and compare it with YOLOv11 [1]. The key improvements in YOLOv12 over YOLOv11 include the introduction of Area Attention module for enhanced global dependency capture in complex scenes, implementation of R-ELAN for optimized multi-scale feature fusion, enhanced Anchor-Free mechanism for simplified target box generation, and improved small target detection capabilities.

Experimental Methods and Results. The evaluation of model performance was conducted using several key metrics, including mAP50 (mean Average Precision at IoU threshold 0.5), mAP50-95 (mean Average Precision across IoU thresholds from 0.5 to 0.95), and various training losses including box regression loss, classification loss, and distribution focal loss. The experimental results revealed significant performance improvements in YOLOv12 compared to YOLOv11. Training metrics showed that YOLOv12 achieved lower box loss values, indicating more accurate target localization and faster convergence during training [2]. The classification loss was also notably reduced, demonstrating improved accuracy in target classification. Validation results further confirmed YOLOv12's superior performance, with lower validation box loss indicating stronger generalization ability in Figure 1.

Performance comparison between the two models showed that YOLOv12 consistently outperformed YOLOv11 across all evaluation metrics. The improved mAP50 and mAP50-95 scores demonstrated enhanced detection accuracy, particularly under strict IoU thresholds. YOLOv12 exhibited superior capabilities in handling complex backgrounds and detecting small targets, which are crucial challenges in SAR image processing [3]. The model showed faster convergence during training and demonstrated more robust performance across various testing scenarios.

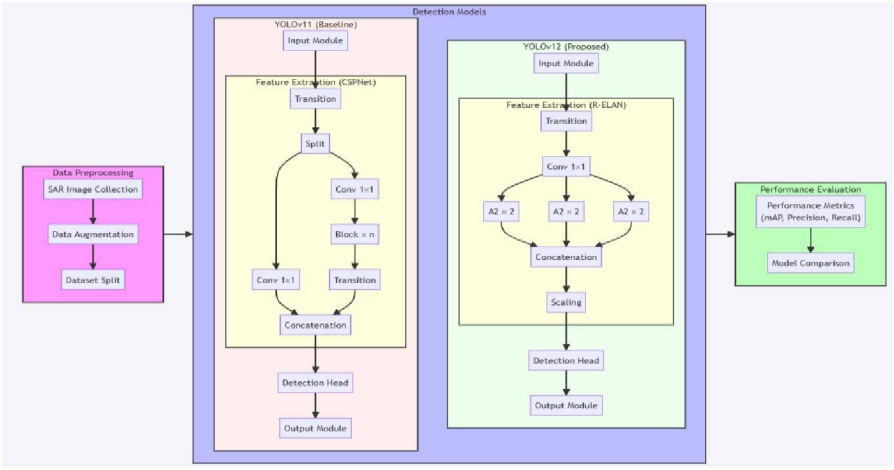

Figure 1 – Comparison Workflow Diagram of YOLOv11 and YOLOv12 for SAR Image Target Detection

YOLOv12 outperforms YOLOv11 across all evaluation metrics. During both training and validation phases, YOLOv12 demonstrates significantly lower loss values (Box Loss, Cls Loss, and DFL Loss), indicating faster convergence and stronger generalization capability. Additionally, YOLOv12 achieves substantial improvements in precision, recall, as well as core metrics such as

mAP50 and mAP50-95, which comprehensively validates its enhanced detection performance in Table 1.

Table 1. Comparison of YOLOv11 and YOLOv12 Performance Metrics

Metric	YOLOv11	YOLOv12	Improvement
Train Box Loss	Higher	Lower	Faster convergence, more accurate localization
Train Cls Loss	Higher	Lower	More accurate classification
Train DFL Loss	Higher	Lower	Better distribution predictions
Val Box Loss	Higher	Lower	Stronger generalization ability
Val Cls Loss	Higher	Lower	More stable classification performance
Val DFL Loss	Higher	Lower	Stronger generalization ability
Precision	Lower	Higher	Lower false positive rate
Recall	Lower	Higher	Lower false negative rate
mAP50	Lower	Higher	Higher detection accuracy
mAP50-95	Lower	Higher	Better performance under strict IoU

Conclusion. Through comprehensive experimental validation, YOLOv12 has demonstrated significant advantages in SAR image target detection tasks. Compared to YOLOv11, it shows notable improvements in detection accuracy and robustness, particularly excelling in small target detection and complex background processing. Although its inference speed is slightly lower than YOLOv11, it still meets real-time detection requirements. The research findings provide important references for the development of SAR image target detection technology, suggesting that YOLOv12's architectural improvements effectively address the unique challenges posed by SAR image processing. Future research can further explore the application of YOLOv12 in more SAR image tasks (such as semantic segmentation and change detection) and combine multimodal data (such as optical images and SAR images) to further improve the detection performance.

List of references:

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