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Advancing Colorectal Cancer Prevention: Region-Guided Polyp Detection in Colonoscopy

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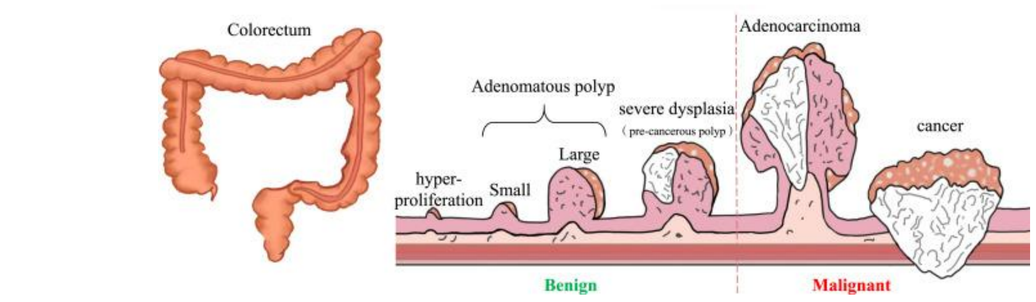
INTRODUCTION & AIM

Colorectal cancer often begins as small polyps that may become cancerous if not detected early. Traditional manual detection during colonoscopy is challenging because polyps vary in size, shape, color, and texture. Recent advances in deep learning, especially YOLO-based detectors and SAM segmentation models, have significantly improved automatic polyp detection and boundary accuracy. However, many models still struggle with small polyps, low contrast, and real-time clinical performance.



The aim of this research is to develop a region-guided hybrid AI framework using YOLOv11, YOLOv11-Seg, SAM, and SAM2 to provide highly accurate and real-time detection of colorectal polyps. The model seeks to improve segmentation quality with clearer and more refined polyp boundaries, reduce the number of missed small or low-contrast polyps, and ultimately support early colorectal cancer prevention. Additionally, the study evaluates the system's effectiveness on the Kvasir-SEG dataset using standard performance metrics to ensure reliability for clinical use.

METHOD

This study primarily used the YOLOv11-Detection model to automatically identify colorectal polyps from colonoscopy images, emphasizing fast, accurate, and anchor-free localization. The model was trained on the Kvasir-SEG dataset using preprocessing steps such as scaling, translation, color jitter, horizontal flipping, and mosaic augmentation to ensure robustness across varying polyp sizes, shapes, and lighting conditions. Alongside YOLOv11-Detection, YOLOv11-Seg, SAM, and SAM2 were also applied to generate pixel-level segmentation masks for comparative evaluation. All models were trained under identical hyperparameters and hardware settings, enabling fair performance comparison. Evaluation was conducted using accuracy, precision, recall, F1-score, IoU, and mAP to measure detection and segmentation effectiveness.

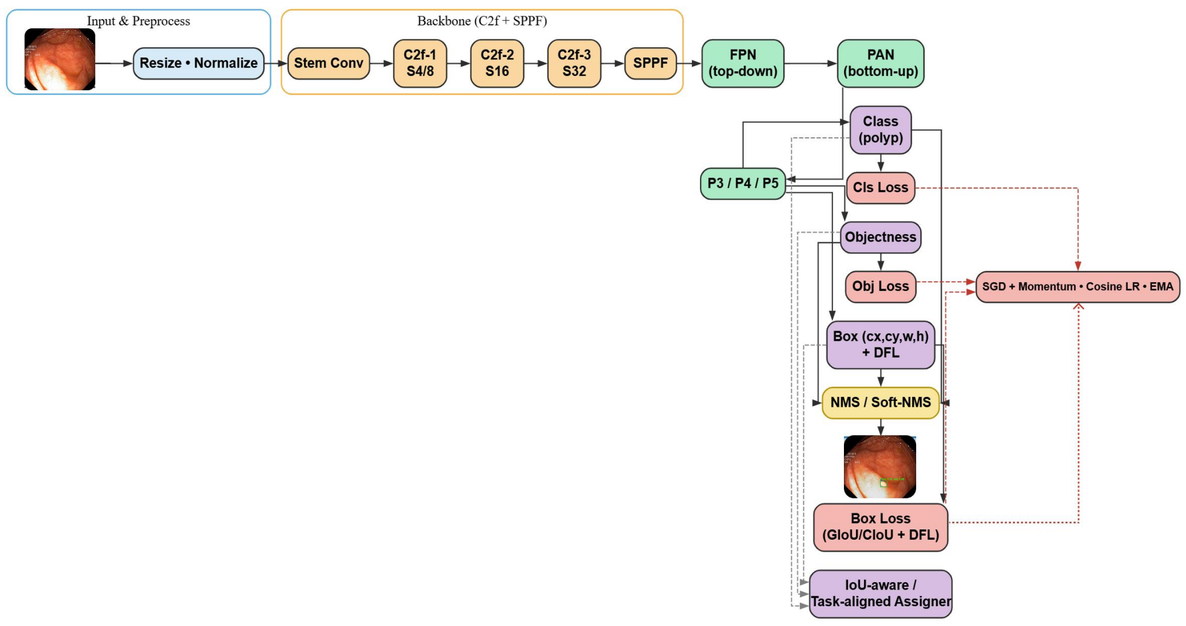


Figure 1: YOLOv11 in Polyp Detection(Best Model)

RESULTS & DISCUSSION

The YOLOv11-Detection model showed stable and consistent learning behavior, as reflected in the loss and performance curves shown in Figure 1.The training and validation losses steadily decreased, indicating smooth convergence without overfitting. Correspondingly, the performance metrics rapidly reached high values and remained stable throughout training. The model achieved **99% accuracy, 100% recall, and an IoU of 0.9764**, confirming precise localization and reliable detection across polyps of different sizes and appearances. In addition to the main detection model, YOLOv11-Seg, SAM, and SAM2 were also applied, which produced accurate segmentation outputs, with SAM2 generating the most refined boundaries. Overall, the results demonstrate that YOLOv11-Detection provides strong and consistent performance suitable for real-time colonoscopy applications.

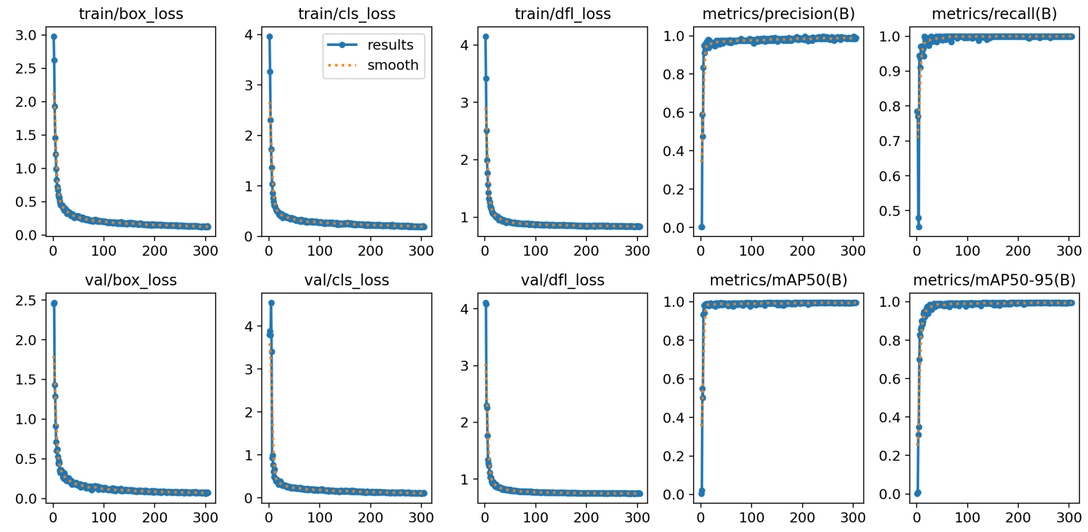


Figure 2. YOLOV11-detection Loss and Performance.

YOLOv11 achieved the strongest detection accuracy with near-perfect recall, minimizing missed polyps crucial for clinical safety.SAM2 provided the sharpest and most stable polyp boundaries, outperforming SAM and YOLOv11-Seg in segmentation.

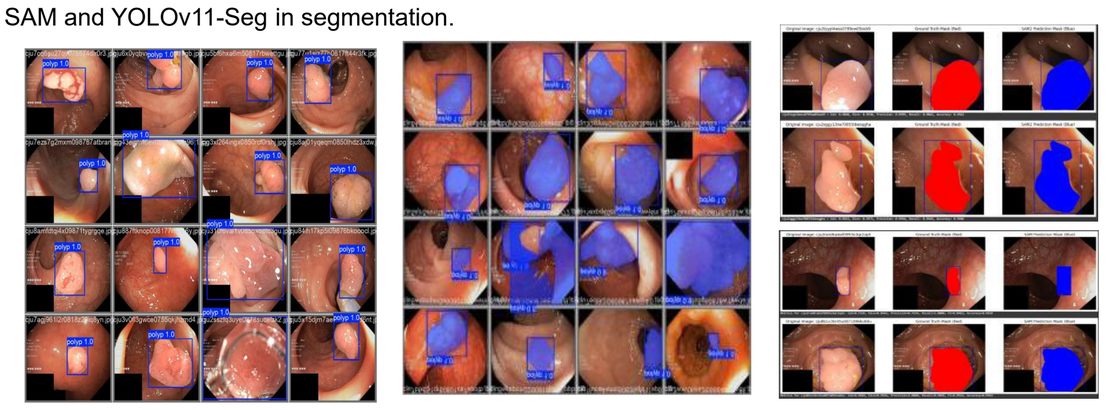


Figure 3: Predicted results of the models
(YOLOv11 Detection; YOLOv11 Segmentation; SAM; SAM2)

Table 1 :Comparative performance of different models.

Model	Precision	Recall	F1-Scrore	IoU	mAP@0.5
YOLOv11-Segmentation	0.9991	1.0000	0.9959	0.9154	0.9909
SAM	0.9898	0.9601	0.9708	0.9500	-
SAM 2	0.9946	0.9660	0.9771	0.9608	-
YOLOv11-Detection (Best model)	**0.9796**	**1.0000**	**0.9897**	**0.9764**	**0.9935**

Table 2 : Comparative analysis with Prior research works

Papers	Method	Precision	Recall	F1-Score	IoU
M. Lalinia and A. Sahafi[1]	YOLOv8	95.60	91.70	92.40	-
P. Ghose, A. Ghose[2]	Fine-tuned YOLOv5 with augmentation	99.01	98.95	98.54	-
B. Si, C. Pang, Z. Wang, P. Jiang, G. Yan[3]	Attention–YOLOv5-Lite-Prune	91.40	74.70	-	-
Wan et al.[4]	YOLOv5	91.3	92.1	91.7	-
Ours (YOLOv11)	**YOLOv11 Detection**	**97.96**	**100.00**	**98.97**	**97.64**

YOLOv11, YOLOv11-Seg, SAM, and SAM2 showed strong performance in detecting and segmenting colorectal polyps. YOLOv11-Detection achieved 99% accuracy and 100% recall, proving effective for real-time use. SAM2 provided the most refined segmentation with a Dice score of 0.9771. Overall, these models greatly improve the accuracy and efficiency of colonoscopy screenings and support early colorectal cancer detection

CONCLUSION

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[1] M. Lalinia and A. Sahafi, "Colorectal polyp detection in colonoscopy images using yolo-v8 network," Signal, Image and Video Processing, vol. 18, no. 8, pp. 2047–2058, 2024.
[2] P. Ghose, A. Ghose, D. Sadhukhan, S. Pal, and M. Mitra, "Improved polyp detection from colonoscopy images using finetuned YOLO-v5," Multimedia Tools and Applications, vol. 83, no. 14, pp. 42929–42954, 2024.
[3] B. Si, C. Pang, Z. Wang, P. Jiang, and G. Yan, "Real-time lightweight convolutional neural network for polyp detection in endoscope images," Journal of Shanghai Jiaotong University (Science), vol. 30, pp. 521–534, 2025.
[4] Wan,J., Chen, B., Yu, Y.: Ployp detection from colorectum images by using attentive yolov5. *Diagnostics* 11(12), 2264(2021)