Deep Learning - Based Colon Polyp Detection System for Early Colorectal Cancer Screening

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Abstract
Colorectal cancer (CRC) is a leading cause of cancer-related mortality globally, where early detection of precancerous polyps is vital for patient survival. Although colonoscopy is the gold standard, manual detection is prone to human error due to clinician fatigue and subtle lesion features. This paper proposes a Deep Learning–Based Colon Polyp Detection System utilizing Convolutional Neural Networks (CNNs) to automate the localization of polyps in real time. The system employs transfer learning with the MobileNetV2 architecture, data augmentation, and advanced preprocessing to achieve high sensitivity and specificity. Experimental observations indicate that the AI-assisted approach reduces the probability of missed polyps, thereby supporting gastroenterologists in clinical decision-making and improving healthcare efficiency.

Keywords: Colorectal Cancer, Colon Polyp Detection, Deep Learning, CNN, MobileNetV2, Transfer Learning, Computer-Aided Diagnosis.

I. INTRODUCTION
Colorectal cancer (CRC) ranks among the top three most commonly diagnosed cancers worldwide. Most CRCs develop from adenomatous polyps over several years, making early screening critical for prevention. While colonoscopy is the primary screening tool, studies show that a significant percentage of small or flat lesions are missed due to clinician fatigue and variable experience levels. Recent advancements in artificial intelligence (AI), particularly deep learning, provide a promising solution by enabling automatic extraction of complex hierarchical features from raw endoscopic images. This work aims to develop a robust, real-time system that assists clinicians as a second observer during colonoscopy procedures.

II. LITERATURE SURVEY
Several studies have explored deep learning approaches for colon polyp detection. Architectures such as SSD with ResNet or VGG backbones enable real-time localization, while YOLO-based detectors emphasize speed and precision. U-Net architectures focus on pixel-level segmentation for precise boundary detection. Despite these advancements, challenges remain, including high false-positive rates, limited generalization across datasets, and computational complexity that limits real-time clinical deployment.

III. PROPOSED METHODOLOGY
The proposed system integrates lightweight deep learning architectures with enhanced preprocessing techniques to improve real-time detection accuracy while maintaining computational efficiency.

A. System Architecture
The system comprises five primary modules: image acquisition for capturing colonoscopy frames; preprocessing involving resizing, normalization, and data augmentation; deep learning detection using a MobileNetV2 backbone; postprocessing with non-maximum suppression to eliminate redundant detections; and visualization using heatmaps to explain detection decisions to clinicians.

B. Transfer Learning Approach
MobileNetV2 pre-trained on the ImageNet dataset is utilized as the feature extractor. The base layers are frozen to preserve generic visual features, while custom classification layers are trained on colonoscopy images to specialize the model for polyp detection.

IV. IMPLEMENTATION DETAILS
The system is implemented in Python using TensorFlow and Keras for model development and training. OpenCV is employed for image and video stream processing. Training is performed using 150×150 input images, a batch size of 32, and data

augmentation techniques including rotation, translation, and horizontal flipping. The classifier consists of a global average pooling layer, a dense layer with ReLU activation, dropout for regularization, and a softmax output layer.

V. RESULTS AND DISCUSSION

The model was validated using an 80:20 training-validation split. The lightweight nature of MobileNetV2 enables efficient deployment in clinical environments without compromising accuracy. Data augmentation improved robustness against lighting variations and scale differences commonly encountered in real-world colonoscopy procedures.

VI. CONCLUSION

This study presents an effective AI-based system for automated colon polyp detection. By functioning as a digital second observer, the system reduces human error and improves adenoma detection rates. Future work will focus on three-dimensional segmentation and large-scale clinical trials to enhance generalizability and reliability.

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