A Swarm-Optimized Hybrid YOLOv8–Random Forest Model for Gastrointestinal Abnormality Identification in Wireless Capsule Endoscopy

C. V. Chakradhar
Research Scholar, Department of CST, S. K. University, Anantapuramu, Andhra Pradesh, India

Dr. T. Bhaskara Reddy
Professor, Department of CST, S. K. University, Anantapuramu, Andhra Pradesh, India

Abstract

Wireless Capsule Endoscopy (WCE) enables non-invasive visualization of the gastrointestinal tract; however, the large volume of acquired frames makes manual inspection labor-intensive and prone to diagnostic variability. To address this challenge, this paper proposes a swarm-optimized hybrid YOLOv8–Random Forest framework for automated gastrointestinal abnormality identification. The proposed method employs YOLOv8 for real-time lesion localization and deep spatial feature extraction, followed by Random Forest classification to enhance robustness and interpretability. Particle Swarm Optimization (PSO) and Grey Wolf Optimizer (GWO) are incorporated to optimize critical hyperparameters of the detection and classification stages. Experiments were conducted on the Kvasir-Capsule dataset using two dataset sizes (4,000 and 8,000 images) with patient-independent splitting. On the 8,000-image configuration, the proposed PSO/GWO–YOLOv8–RF model achieved an accuracy of 98.24%, precision of 97.92%, recall of 97.68%, F1-score of 97.80%, and an AUC of 0.992. For the 4,000-image setting, the model achieved an accuracy of 97.82% and an AUC of 0.986. In addition, the optimized framework obtained a mean Average Precision (mAP@0.5) of 82.6%, significantly outperforming standalone YOLOv8 and non-optimized hybrid variants. The results demonstrate that the synergistic integration of deep learning localization, ensemble classification, and swarm-based optimization provides a highly accurate and reliable decision-support system for clinical WCE diagnostics.

Keywords

Wireless Capsule Endoscopy, YOLOv8, Random Forest, Swarm Intelligence, Particle Swarm Optimization, Medical Image Analysis.