



Chapter 8

Hybrid Metaheuristic Optimization for Neural Networks in Biomedical Imaging

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ABSTRACT

Advancing biomedical image processing requires sophisticated optimization methods to improve segmentation and classification accuracy. This chapter explores hybrid metaheuristic approaches for enhancing neural networks in medical imaging, integrating evolutionary-inspired algorithms like Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Ant Colony Optimization (ACO). These techniques optimize hyperparameters, enhance computational performance, and mitigate inconsistencies in deep learning models. By combining metaheuristic methods with deep learning, researchers address challenges such as medical image variability and operational noise, leading to more robust and efficient models. Case studies

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results confirm that hybrid optimization methods significantly improve segmentation and classification in biomedical imaging. Additionally, the chapter reviews existing applications and their role in future AI-driven healthcare solutions. It presents algorithm strategies, implementation techniques, and evaluation methods to aid experts in biomedical image analysis.

INTRODUCTION

The analysis of diseases becomes more effective through biomedical image processing for both diagnostic segmentation and classification procedures. Traditional neural networks demonstrate problems in hyperparameter optimization because of network architecture optimization thus generating inconsistent results in medical image analysis procedures. Scientists need particular requirements to research natural evolutionary processes which lead to the development of metaheuristic algorithms for mathematical calculation optimization problems. Using GA and PSO and ACO together as parts of hybrid metaheuristic algorithms generates improved neural network performance, (Ling, Huang, & Zhuoet, 2022). Several algorithms help developers create processing systems that boost accuracy performance and offer flexible operation and shorter processing times. Deep learning and evolutionary techniques together produce automated solutions which effectively remedy different processing errors related to irregular data entry and information interference. The section investigates hybrid metaheuristic application to biomedical neural networks via descriptions of practical benefits along with achievable results from implementation, (Ding et al., 2023).

Overview of Biomedical Image Processing and Its Significance

Medical research activities fully depend on biomedical image processing techniques for the correct interpretation of MRI and CT scan and X-ray slides. Doctors who work in healthcare field conduct advanced computer operations to detect diseases in images which enables them to establish proper treatment approaches for patients. Medical industry needs automated processing solutions to speed up their development pace in order to achieve results that match image processing speeds. The pattern detection capability by neural network-based deep learning models remains unavailable because human analysts do not have the ability to recreate this process, (Duan, Han, & Tian, 2019). Medical imaging applications need to upgrade their performance results through precision enhancement and operation speed optimization where optimization methods serve as essential pathways to such achievements.

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