Chapter 14

Overcoming Barriers in Metaheuristic Neural Network Optimization for Biomedical Imaging

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ABSTRACT

Combining metaheuristic algorithms with neural networks significantly enhances biomedical image segmentation and classification. Researchers optimize neural networks using evolutionary-based strategies like genetic algorithms (GA), particle swarm optimization (PSO), and ant colony optimization (ACO) to improve accuracy and reduce noise. These hybrid approaches help with feature selection, adaptive learning, and algorithm tuning, though computational limitations and parameter optimization remain challenges. Deep learning applications in biomedical imaging benefit from these optimizations, achieving better diagnostic precision and software-assisted clinical evaluations. Scalability and interpretability are essential

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for real-world deployment. Quantum-inspired metaheuristics also show promise in improving deep reinforcement learning, making image processing more efficient and robust. By integrating these techniques, both scientists and healthcare practitioners can advance their AI-based understanding of biomedical imaging.

INTRODUCTION

In modern healthcare, biomedical image processing has become an essential part for accurate diagnosis, early detection of diseases, and personalized treatment plans. The recent growth of deep learning and neural networks has enhanced our capacity to interpret complicated medical images. Furthermore, remodel training and optimization of neural networks for valued output can be a problematic approach due to challenges associated with high dimensionality, noisiness, and small sample sizes of annotated datasets, (Algorithms for biomedical image analysis and processing, n.d.). Thus, academics have opted for alternative methods to increase model performance, including metaheuristic algorithms. Always based on instinct or evolutionary determinants, metaheuristic algorithms provide adaptable, effective flexibility to functionality optimization as an optimization strategy, which is particularly appropriate for configuration optimization of neural networks, feature selection, and convergences speed optimization adaptation tasks within biomedical imaging. Popular techniques for optimization such as Genetic Algorithms, Particle Swarm Optimization, and Ant Colony Optimization have been effectively utilized to enhance segmentation and classification practices in biomedical imaging applications, (Almutairi et al., 2023).

Despite their potential, the combination of metaheuristic algorithms with neural networks creates multiple challenges, including computational complexity, hyperparameter tuning, and scalability. In addition, many models are black-box algorithms, which raises issues regarding their interpretability and utility in a clinical context. This chapter investigates the use of optimization through metaheuristics and neural networks within biomedical image processing. Dashdorj and Song (2019) discuss the applications of main concepts, hybrids and both approaches, while investigating obstacles to implementation. The chapter concludes by giving a look at the more advanced methods of work and some future research routes. Finally, the purpose of this chapter is to provide insight and expansion for those interested in the use of AI in medical imaging.