


Chapter 11

Metaheuristics for Transfer Learning and Model Generalization in Biomedical Imaging

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ABSTRACT

By enabling automated analysis and interpretation of medical imaging, biomedical image analysis contributes significantly to modern medicine. Medical photos are automatically labeled or categorized according to their content using biometric

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image classification. Consequently, we present a new hybrid meta-heuristic and deep learning-based fusion model for biomedical picture interpretation in this chapter. A paradigm shift and several notable advancements have resulted from the use of multi-step transition learning to medical picture interpretation. High-level features that may be expertly tailored to the particular needs of the target medical imaging task can be extracted from the source domain using this method. This flexibility is especially helpful in situations when gathering a lot of labeled medical data is time-consuming or difficult.

INTRODUCTION

Biomedical image analysis plays a pivotal role in medical research and healthcare-related fields using advanced computational techniques to obtain meaningful information from medical images generated by MRI, CT, X-ray, and microscopy. This domain integrates artificial intelligence, machine learning, and computer vision to improve disease diagnosis, treatment planning, and biomedical research (Ahmed et al. 2023). Through image segmentation, feature extraction, and classification methods, high accuracy in the identification of abnormalities, such as tumors, fractures, or infections, is achieved through biomedical image analysis (Humpire-Mamani et al., 2023). Deep learning implementations, with CNNs leading the way, have provided significant improvements in automated medical image interpretation, thereby decreasing human error and increasing efficiency in a clinical workflow. Early diagnosis, personalized medicine, and the development of AI-based diagnostic tools geared toward improving patient outcomes and contributing to medical science are among the most important areas of work in this sector (Lai, 2024).

Transfer learning is a radical option for solving the problem of insufficient data in biomedical imaging applications. According to Jia et al. (2023), instead of building models from scratch, transfer learning leverages pretrained models, which are typically constructed based on large-scale datasets of natural images such as ImageNet, to extract features and tune them for medical imaging applications. Direct translation to other courses is not always appropriate, but varying image characteristics can arise from domain to domain. Fine-tuning strategies, domain adaptation, and optimization of transferred features are required to improve the generalization of the model. According to Zhao et al. (2024), metaheuristics may play a critical role in transferring learning through the superiority of hyperparameter optimization, a method of feature selection, and the best adaptation strategy.

Metaheuristic methods are nature-inspired optimization algorithms that produce near-optimal solutions to several complex problems in cases where mathematics does not provide explicit models. Metaheuristic algorithms include Genetic Algo-

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