Comparative Analysis of Particle Swarm Optimization and Whale Optimization Algorithm for Medical Image Enhancement

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Abstract:

Medical images play a critical role in diagnosing and treating various diseases, making their quality a crucial factor in clinical decision-making. However, raw medical images often suffer from issues such as low contrast, noise, blurring, and poor illumination, which can erase important anatomical details and reduce diagnostic accuracy. Traditional enhancement techniques, such as histogram equalization and unsharp masking, may improve image quality but often fail to effectively balance contrast enhancement with noise suppression. Therefore, advanced and intelligent image enhancement methods are essential to ensure clearer visualization of critical features like tumors, blood vessels, and tissue structures. Metaheuristic optimization algorithms (MOAs) are popularly deployed for enhancing images most especially medical image enhancement (MIE) purposes. However, with an ever-increasing rate of newer MOAs being proposed in the literature, the question arises as to whether there exist any significant advantage(s) among these different MOAs, particularly as it pertains to MIE. This paper compares two metaheuristic algorithms including particle swarm optimization (PSO) and whale optimization algorithm (WOA) for medical image enhancement. Firstly, rather than utilizing the number of generations to evaluate the performance of MOA, the fitness computation rate was used. This allows MOAs to be compared in a more unbiassed approach. Secondly, the use of a transformation function and effective evaluation function as our objective function in both MOAs is used in the study. Then, medical images were obtained from the Medpix dataset with representative samples selected from across the different parts of the body for MIE evaluation purposes. Results show that the WOA algorithm performed slightly better than PSO over an average of 1000 Monte Carlo trials. The timing performance demonstrated that there was little or no statistically significant difference in the real-time processing speed of the two methods, especially when investigated under the same fitness computation rate (FCR). Findings further show that both metaheuristic algorithms enhance the medical images, that will improve medical diagnosis and decision making thereby saving more lives.