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The Role of Metaheuristic Approaches in Engineering Problems

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Abstract : Many types of problems can be solved using traditional analytical methods. However, these methods take a long time and cause inefficient use of resources. In particular, different approaches may be required in solving complex and global engineering problems that we frequently encounter in real life. The bigger and more complex a problem, the harder it is to solve. Such problems are called Nondeterministic Polynomial time (NP-hard) in the literature. The main reasons for recommending different metaheuristic algorithms for various problems are the use of simple concepts, the use of simple mathematical equations and structures, the use of non-derivative mechanisms, the avoidance of local optima, and their fast convergence. They are also flexible, as they can be applied to different problems without very specific modifications. Thanks to these features, it can be easily embedded even in many hardware devices. Accordingly, this approach can also be used in trend application areas such as IoT, big data, and parallel structures. Indeed, the metaheuristic approaches are algorithms that return near-optimal results for solving large-scale optimization problems. This study is focused on the new metaheuristic method that has been merged with the chaotic approach. It is based on the chaos theorem and helps relevant algorithms to improve the diversity of the population and fast convergence. This approach is based on Chimp Optimization Algorithm (ChOA), that is a recently introduced metaheuristic algorithm inspired by nature. This algorithm identified four types of chimpanzee groups: attacker, barrier, chaser, and driver, and proposed a suitable mathematical model for them based on the various intelligence and sexual motivations of chimpanzees. However, this algorithm is not more successful in the convergence rate and escaping of the local optimum trap in solving high-dimensional problems. Although it and some of its variants use some strategies to overcome these problems, it is observed that it is not sufficient. Therefore, in this study, a newly expanded variant is described. In the algorithm called Ex-ChOA, hybrid models are proposed for position updates of search agents, and a dynamic switching mechanism is provided for transition phases. This flexible structure solves the slow convergence problem of ChOA and improves its accuracy in multidimensional problems. Therefore, it tries to achieve success in solving global, complex, and constrained problems. The main contribution of this study is 1) It improves the accuracy and solves the slow convergence problem of the ChOA. 2) It proposes new hybrid movement strategy models for position updates of search agents. 3) It provides success in solving global, complex, and constrained problems. 4) It provides a dynamic switching mechanism between phases. The performance of the Ex-ChOA algorithm is analyzed on a total of 8 benchmark functions, as well as a total of 2 classical and constrained engineering problems. The proposed algorithm is compared with the ChoA, and several well-known variants (Weighted-ChoA, Enhanced-ChoA) are used. In addition, an Improved algorithm from the Grey Wolf Optimizer (I-GWO) method is chosen for comparison since the working model is similar. The obtained results depict that the proposed algorithm performs better or equivalently to the compared algorithms.

Keywords : optimization, metaheuristic, chimp optimization algorithm, engineering constrained problems
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