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β-Chaotic map enabled Grey Wolf Optimizer

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HIGHLIGHTS

- A bridging mechanism inspired from β function is proposed for Grey Wolf Optimizer.
- Evolved β-GWO is benchmarked on shifted and biased and CEC-2017 functions.
- Comparative analyses with variants of GWO and other algorithms are presented.
- Applications of β-GWO are reported on real problems.

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ABSTRACT

The diversification (exploration) and intensification (exploitation) are two main attributes of any population-based metaheuristic algorithm. It is essential for any algorithm that in exploration phase the search space is utilized and explored properly through random behavior, on the other hand, the progression of the search in a viable direction to obtain global minima, should be performed through strategic behavior in exploitation phase. A proper balance between these two can be achieved by an adaptive mechanism in every algorithm. Robustness of an algorithm is judged by the efficacy of these two attributes along with the efficiency of the bridging mechanism. In literature, the positive impact of inculcation of chaotic sequences on the efficacy of these attributes has been reported. With this motivation, the paper presents an adaptive bridging mechanism based on β-chaotic sequence for the improvement of Grey Wolf Optimizer (GWO). The control vector of classical GWO is integrated with the β-chaotic sequence for better exploration and exploitation virtues. The new variant β-GWO is benchmarked on two benchmark suites 1 and 2 that include 12 shifted and biased functions and 29 Congress on Evolutionary Computation-2017 (CEC-2017) functions. Sensitivity Dependence of Initial Conditions (SDIC) is performed for tuning the initial parameters. The comparison of the proposed variant with other contemporary algorithms is carried out and different statistical tests are performed to judge the efficacy of the proposed variant. Further, the applicability of the proposed variant is checked with two real engineering problems namely frequency modulated sound waves parameter estimation problem and strategic bidding in the energy market. Results reveal that the proposed chaotic variant exhibits better exploration and exploitation qualities.

1. Introduction

Non-convex and black-box optimization problems involving multi-dimensional real search spaces, often pose a severe challenge to the traditional mathematical programming based solvers. In addition, some instances of such problems may not clearly define the bounds on the decision variables while involving stochastic parameters (often due to noise). These problems can be continuous, discontinuous, constrained, or unconstrained in nature. While searching the powerful paradigms to solve such hard optimization problems, the metaheuristic algorithms have been developed by the researchers for over last four decades or more. Metaheuristics, founded on the basis of simulation and mimicry of nature, provide the advantages in terms of requiring no derivative information of the function, being insensitive to initialization and being adaptive as well as simple. In contrast to the traditional problem-specific heuristic methods, these metaheuristic optimization algorithms can be applied in a black-box manner and without presuming domain knowledge about the problem at hand [1].

A metaheuristic method is a problem independent higher level heuristic method that can be employed to solve many hard optimization problems. The use of metaheuristic algorithms in real applications has increased from last few years. The metaheuristic

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