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A Hybrid Grey Wolf Optimizer and Artificial Bee Colony Algorithm for Enhancing the Performance of Complex Systems

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Abstract

In this paper, a novel hybrid algorithm based on grey wolf optimizer (GWO) and artificial bee colony (ABC) algorithm called GWO-ABC is proposed to inherit their advantages and overcome their drawbacks. In GWO-ABC algorithm, wolves adopt the information sharing strategy of bees to promote their exploration ability while wolves keep their original hunting strategy to retain exploitation ability. Moreover, a new method based on chaotic mapping and opposition based learning is proposed to initialize the population. The aim for this new initialization method is to generate an initial population with already better individuals to set a solid ground for rest of the GWO-ABC algorithm to execute. The sole motivation behind incorporating changes in GWO is to help the algorithm to evade premature convergence and to steer the search towards the potential search region in faster manner. To assess the performance of the GWO-ABC, it is tested on a test bed of 27 synthesis benchmark functions of different properties; and result are compared with 5 other efficient algorithms. From the analysis of the numerical results, it is apparent that the projected changes in the GWO ameliorate its overall performance and efficacy especially while dealing with noisy (problem with many sub-optima) problems. Furthermore, GWO-ABC is applied to design an optimal fractional order PID (FOPID) controllers for variety of typical benchmark complex transfer functions and trajectory tracking problem of 2 degree-of-freedom (DOF) robotic manipulator. All simulation results, illustrations, and comparative analysis establish the GWO-ABC as viable alternative to design a controller with optimal parameters and enhance the performance of complex systems.

Keywords: Grey wolf optimizer, Artificial Bee Colony, Optimum controller design, Hybrid algorithms.

1. Introduction

Over the last decade, distinct nature based phenomena as well as physical properties of natural species have attracted the attention of researchers from various disciplines. Having inspired by such beautiful different type of natural phenomena, researchers have proposed various algorithms- nature inspired optimization algorithm- to solve cumbersome optimization problems [1, 2]. These nature inspired optimizers are found to be effective in finding the optimal solution than deterministic algorithms, therefore, recently they are preferred highly to solve real life optimization problems [3]. The salient features of these metaheuristic algorithms (MAs) are: (a) unlike deterministic method, they are derivative free and depend only on fitness function, therefore, easy to implement, (b) since no prior problem knowledge of problem as well as the domain of the problem, they can be applied in the wide range of problems irrespective of domain, (c) contrary to deterministic methods, they work on a set of solutions; and these solutions are refined over course of iterations. Finally, this population based nature helps them in escaping from the potential dangerous situations, such as premature convergence and local optima stagnation. Thus, the MAs have clear age over deterministic algorithms in terms of exploitation and exploration techniques, capability to avoid entrapment at local optima, and convergence characteristics [4].

Earlier, evolutionary algorithms like genetic algorithm (GA) [5] and differential evolution (DE) [6] were very rampant in the literature. In recent years, particle swarm optimization (PSO) [7], artificial bee colony (ABC) [2], grey

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