Comparative Study of Fuzzy Symbiotic Organism Search Variants for Pairwise Test Suite Generation

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Abstract

Metaheuristic algorithms have been utilized for the past 30 years as a core in solving complex optimization problems because of their ability to explore (i.e., roaming the entire search space) and exploit (i.e., searching around the neighbourhood). Most of these algorithms rely on parameter control to balance this exploration and exploitation to find the best solution. However, tuning these parameters is problematic as they are problem-dependent, and an improper tuning of these parameters undesirably increases computational efforts and yields sub-optimal solutions. Fuzzy Symbiotic Organism Search (FSOS) is among the latest parameter-less meta-heuristics algorithm created to solve optimization problems by having an adaptive exploration and exploitation based on the search need. As this new algorithm is dependent on a Fuzzy Inference System (FIS), the interest in investigating the fuzzy design choice in FSOS has emerged to make sure the choices of the Fuzzy Inference System in FSOS are capable of solving the general optimization problem without overfitting or underfitting. In this paper, we present the effects of different versions of fuzzy rules in the FSOS Fuzzy Inference System on the performance of FSOS. Experimental results demonstrate that the original FSOS with fuzzy rules that cover most of the antecedent combinations supersedes the other combination by 0.7% (FSOS1) and 0.3% (FSOS2).

1. Introduction

The metaheuristics method has been used for more than 30 years to solve the optimization problem by finding the best (feasible) solutions in an acceptable amount of time. Metaheuristics work by evaluating potential solutions and manipulating them further to search for a better solution using global search (exploration) and local search (exploitation) operators. Local Search operators enable small changes around the potential solutions, while global search will let the potential solutions explore further.

Balancing the need between exploration and exploitation is crucial as solutions might be trapped in local optima when too much local search is employed. In contrast, excessive use of global search might hinder potential solutions from reaching convergence.

Metaheuristics such as Simulated Annealing[1], Particle Swarm Optimization(PSO)[2], Artificial Neural Network (ANN)[3], Honey Badger Algorithm(HBA)[4], and Atomic Orbital Search(AOS)[5] depends on parameter control to adjust the balance between local search and global search. Nonetheless, tuning this parameter is a delicate process and time-consuming as the tuning might not be fit for all approaches.

Thus, emerged another type of metaheuristics that does not depend on any control parameters (except the number of populations and iteration times), such as the Jaya algorithm[6], Teaching Learning Based Optimization (TLBO)[7], Chaotic Fruitfly Optimization Algorithm (CFOA)[8], Sine Cosine Algorithm (SCA)[9], and Grey Wolf Optimizer(GWO)[10] to name a few. These metaheuristics typically have a minimum of two operators (one for local search, one for global search), which will be repeated one after the other until the end of iterations. This pre-set sequence proved to be successful in getting rid of tuning difficulty; however, leaping into a global search when the solutions are trying to converge will further move the solutions away. The same goes when the solutions are forced to converge when they still need to explore. As such, finding the optimal solution promptly can be potentially hindered.

The Symbiotic Organism Search Algorithm (SOS)[11] has recently gained significant attention for addressing general optimization problems. The unique feature of SOS is that it is a parameter-free meta-heuristic algorithm (i.e., no specific control parameters) with a straightforward analogy of three general symbiotic associations (i.e., mutualism, commensalism, and parasitism) of different species in an ecosystem. Within each iteration of SOS, the individual population undergoes a fixed sequence of update search operators defined by mutualism, commensalism, and parasitism.

Although simplifying the overall implementation, the current SOS approach hinders diversity and can cause unwanted entrapment in local optima as the movement of the individual search agent is subjected to the same fixed sequence of search operators throughout the overall search process. Addressing this issue, a new SOS variant, Fuzzy Symbiotic Organism Search (FSOS), has been created [12].