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mNAFSA: A novel approach for optimization in dynamic environments with global changes

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ABSTRACT

Artificial fish swarm algorithm (AFSA) is one of the state-of-the-art swarm intelligence algorithms that is widely used for optimization purposes in static environments. However, numerous real-world problems are dynamic and uncertain, which could not be solved using static approaches. The contribution of this paper is twofold. First, a novel AFSA algorithm, so called NAFSA, has been proposed in order to eliminate weak points of standard AFSA and increase convergence speed of the algorithm. Second, a multi-swarm algorithm based on NAFSA (mNAFSA) was presented to conquer particular challenges of dynamic environment by proposing several novel mechanisms including particularly modified multi-swarm mechanism for finding and covering potential optimum peaks and diversity increase mechanism which is applied after detecting an environment change. The proposed approaches have been evaluated on moving peak benchmark, which is the most prominent benchmark in this domain. This benchmark involves several parameters in order to simulate different configurations of dynamic environments. Extensive experiments show that the proposed algorithm significantly outperforms previous algorithms in most of the tested dynamic environments modeled by moving peaks benchmark.

1. Introduction

Optimization plays a major role in business and engineering domains. It is also the heart of many processes that take place in nature. Optimization problems include many simple routine problems such as choosing the best path to destination, as well as very complex industrial controls. In fact, in many optimization problems, the best result is sought while spending the least amount of cost. In order to solve optimization problems, a cost function is normally designed first. Then, the goal is to find the input parameters that minimize the cost function by the use of mathematical or intelligent methods. When optimization problems are too complex, using mathematical methods becomes extremely difficult or even impossible. For such problems, intelligent methods adopted from nature can be used.

Optimization problems can be categorized according to different criteria. One criterion is whether the optimization problem is static or dynamic. In problems with static environments, the problem remains unchanged in the course of time, whereas in dynamic problems, the problem changes over time. Since many real-world problems have parameters that are time-variant, it can be concluded that optimization in dynamic environments is of paramount importance. However, dynamic factors have been ignored in most of the research conducted so far on optimization. This causes the solutions to get distant from those usable in the real world. For instance, the job scheduling problem may be pointed out. In this problem, the goal is to find the best order of carrying out n independent tasks on m sources, in a manner that the completion time of all of the tasks is minimized. Different types of dynamicity may be observed in these problems that have been overlooked by considering the problem as a static one. Introduction of a new job to the system while jobs are being performed, failure of a resource during operation, addition of a resource after repair, etc. are instances of changes that may occur to the system.

In view of the importance of optimization in dynamic environments, numerous researchers and scientists attempt nowadays to

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