ABSTRACT

In this research, a study was carried out to exploit the hybrid schemes combining two classical local search techniques i.e. Nelder–Mead simplex search method and bidirectional random optimization with two meta-heuristic methods i.e. the shuffled frog leaping and the shuffled complex evolution, respectively. In this hybrid methodology, each subset of meta-heuristic algorithms is improved by a hybrid strategy that is combined from evolutionary process of each subset in related algorithm and a local search method. These hybrid algorithms are evaluated on low and high dimensional continuous benchmark functions and the obtained results are compared with their non-hybrid competitors. The obtained results demonstrate that the hybrid algorithm combined from shuffled frog leaping and Nelder–Mead simplex has a better success rate but a higher number of function evaluations on low-dimensional functions than the shuffled frog leaping. Whereas on high-dimensional functions it has a better success rate and a faster performance. Also the hybrid algorithm combined from shuffled complex evolution and bidirectional random optimization obtains a better performance in terms of success rate and function evaluations than shuffled complex evolution on low dimensional functions; whereas on high-dimensional functions, it obtains a better success rate but a slower performance. Also a comparison of our hybrid algorithms with the other evolutionary algorithms reported in the literature confirms our proposed algorithms have the best performance among all compared algorithms.

INTRODUCTION

Two of the recent algorithms in the class of stochastic search methods and evolutionary algorithms (EAs) are shuffled complex evolution (SCE) (Duan et al., 1992) and shuffled frog leaping (SFL) (Eusuff & Lansey, 2003). These algorithms are two stochastic optimization methods which use partitioning and shuffling processes. Partitioning and shuffling processes by sharing past experiments of each member with other members, help to improve the
quality of solution. In the partitioning process, the population is partitioned into several subsets called complexes and memeplexes in the SCE and SFL respectively. After independent improvement of each subset, in the shuffling process all member of subsets are shuffled and new subsets are formed.

The SCE is a general-purpose global optimization algorithm that combines the strengths of controlled random search (CRS) algorithm (Holland, 1975), competitive evolution and complex shuffling. Each of complexes in the SCE, are evolved in the direction of global improvement, using a competitive evolution method based on the Nelde-Mead simplex search (NM) (Nelder and Mead, 1965). Most of papers which have used from the SCE, have applied it on parameter estimation and calibration in hydrological models (see Cooper et al., 2007; Yu & Liong, 2007; Barakat & Altoubat, 2009; Dotto et al., 2012; Guo et al., 2013) but the SCE have been widely employed to solve different optimization problems such as unconstrained optimization (Mariani & Coelho 2011), phase stability, phase equilibrium and chemical equilibrium problems (Fateen et al., 2012) and efficient surface wave analysis (Song et al., 2012).

The SFL is recently proposed EAs to be successful approaches for function optimization. This algorithm was inspired from social researching of frogs for food resources derived by combining the concepts of the SCE and particle swarm optimization (PSO) (Kennedy & Eberhart, 1997) algorithms. The SFL to improve members of memeplexes uses a process similar to the PSO algorithm. The SFL has been applied on a wide variety of optimization problems such as optimally tune parameters of a fuzzy logic controller (Nguyen & Huynh 2008), multi-user detection problem (Zhijin et al., 2008), unit commitment problem (Ebrahimii et al., 2011), resource-constrained project scheduling problem (Fang & Wang, 2012) and Knapsack problem (Li et al., 2012).

While evolutionary algorithms (EAs) are very effective to find optimal solutions, they can be further improved by adding a suitable local search methods. The non-hybrid EAs have generally a fast convergence rate. For many cases, this fast convergence, because of lack of enough exploration with a great probability, may lead to trapping in a local optimum. To overcome this drawback, hybrid algorithms are efficient and effective methods. A hybrid algorithm with maintaining the correct balance between exploration and exploitation, combines benefits of different algorithms in order to generate a new algorithm that has a better performance than its former ingredient.

The SCE finds efficiently the neighborhood of global optimal point but for many cases, it is not able to converge exactly into individual optimal point. In this paper, to overcome this problem, a hybrid SCE that combines the SCE and bidirectional random optimization (BRO) (Matyas, 1965) is proposed. This hybrid method uses the BRO as a local search method to carry out a deep search of the found regions by the SCE. On the other part, the SFL is an algorithm with suitable ability to search in determinate space but it can not explore sufficiently whole search space. To overcome this problem, a same strategy uses to hybridize the SFL with the NM method.

To hybridize the EAs using by the NM and random optimization (RO) has been investigated in many studies. Wang et al. (2011) by combining differential evolution (DE) and NM simplex search, proposed an effective hybrid algorithm named NMDE. Vakil Baghmisheh et al. (2012) used a hybrid PSO and NM (PS-NM) for estimating the crack location and depth. The hybrid PS–NM was made-up of a modified PSO, aimed to identify the most promising areas, and a NM for performing local search within these areas. A hybrid method that combined the bacterial foraging (BF) algorithm with the Nelder–Mead (NM) method (called BF–NM algorithm) is used to solve the economic load dispatch proposed by Hooshmand et al. (2012). Elbeltagi and Hegazy (2005) used from a local search method similar to RO, is called memetic local search, for the memetic algorithms (MAs) that are a version of hybrid genetic algorithms. Vakil-Baghmisheh and Ahandani (2012) proposed a differential
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