Memetic optimization algorithm with many global optimization methods

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Abstract

The memetic algorithms are combination of global and local optimization methods. Such combination gives chance to enhance advantages and reduce disadvantages of both group of algorithms. The goal of the paper is presentation of algorithm combining few types of global optimization techniques like evolutionary algorithms, particle swarm optimization and artificial immune system with local conjugate gradient algorithm. The discussed algorithm is supported with database of solution and procedure for data exchange between algorithms. The possible application of presented algorithm are optimization of atomic structures.

Keywords: memetic algorithm, evolutionary algorithm, particle swarm optimization, artificial immune system

1. Introduction

The memetic algorithms also known as hybrid algorithm are developed during last 20 years. The first time the memetic algorithm name was used in the report of Moscato [6]. The hybrid evolutionary name was used by Orantek [8,9] for similar approach. The local optimization algorithms have long history, they are very useful and fast in optimization of problem with unimodal objective function. The problem occurs when multimodal objective function is optimized, the starting point of local optimization algorithm can decide about local or global optimum result. On the other hand the global optimization algorithms can deal with problems with many local optima, but the main drawback is long time of computations and the problem with getting to the exact optimum location. The global optimization algorithm have good probability of finding basin of attraction of the global optimum - the very good starting point for local optimum algorithms. The memetic evolutionary algorithms can be built on top one of the global optimization algorithm or few of them can be used in the same time. The global optimization algorithms inspired by biological system of cells, organism or species are used in the presented algorithm. The global algorithms have similarities, like set of designs present in each iteration of algorithms, but also have some differences which should be taken into account.

The memetic algorithm is presented in following section, also the procedures of exchanging information about designs between algorithms are given in details.

2. The memetic optimization algorithm

The two main parts of the memetic algorithms are local and global optimization methods. The local methods are in most cases used only for part of the designs. The presented algorithm use the local optimizer for every design due to the specific application of the algorithm - the optimization of atomic structures [7]. The problem is highly multimodal and the algorithm tries to search new candidates for solutions in design space by making "jumps" between local optima [4].

The flowchart of the memetic algorithm is shown in Fig. 1. The initial population - set of designs are created on the beginning, the local optimization is performed for each design separately. The designs are modified during local optimization and undergo procedures of global optimization algorithm selection (if present in global algorithm) and modifications of designs. The objective function is computed only during local optimization. The process of optimization is finished after termination condition is satisfied. The condition typically found in global optimization algorithms, like maximum number of iterations, constant value of objective function for some prescribed number of iterations, can be used.



Figure 1: The memetic optimization algorithm

The presented algorithm is build on top of three types of global algorithms. Each algorithm can be used many times, so we can have many algorithms working together. The global algorithms have separated set of designs. The designs are exchanged between global algorithms every few iterations in memetic algorithm. The separation of designs works similar to multi-populations (or subpopulations) approach known from the evolutionary algorithms [3].

The flowchart of the memetic algorithm with many global optimization methods is presented in Fig. 2.

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The Particle Swarm Optimization (PSO) [2] operates on designs defined by design variables - locations of particles but also speed of particles. The speed of particles are typical parameters for each design in PSO. During the transfer of design to the PSO, the speed vector for the design can be computed on the basis of two iterations of the optimization algorithm on the basis of designs variables change.

The Artificial Immune System (AIS) [1] operates on designs coded into cells. The two type of cells are used in most clonal selection algorithms - the memory cells and their clones. The exchange of designs in this case is performed by introducing the designs from other algorithms as a memory cell.

The designs are coded into genes in Evolutionary Algorithms (EA) [5]. The introduction of designs can be performed in selection process. The new designs have chance to survive and modify future directions of evolution.



Figure 2: The memetic algorithm with many global optimization methods

The optimization algorithm is also supported by solutions database. The designs previously analyzed by local algorithm obtain objective function value stored in the database.

3. Summary

The memetic optimization algorithm with many global optimization methods was presented in the paper. The use of AIS, EA and PSO leads to better chance of obtaining area near the global optimum, the local optimization algorithm allow to reach exact value of the optimum. The each type of optimization algorithm have many parameters, so the total number of parameters is high. These can lead to difficulties with proper choice of parameters values, but the multipopulation-like approach lets us think about each of the algorithms separately, so typical parameters for each of them can be used. The main disadvantage of the presented method is computation time due to high sum of numbers of designs in each global algorithm. The goal of optimization problem is not reducing the computation time but obtaining the location of global optimum.

The presented memetic algorithm will be used for discovering new stable atomic structures. Due to the massive amount of local optima the approach were each design is modified by local optimization algorithm can be seen as a good approach which usefulness have been proven in previous research.

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