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Gbest-guided Artificial Chemical Reaction Algorithm for global numerical optimization

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Abstract

Chemical reaction(ACR) optimization algorithm invented recently by Bilal Alatas is a heuristics algorithm. However, there is still an insufficiency in ACR algorithm regarding its solution search equation, which is good at exploration but poor at exploitation. Inspired by Particle swarm optimization, we propose an improved ACR algorithm called gbest-guided ACR (GACR) algorithm by incorporating the information of global best (gbest) solution into the solution search equation to improve the exploitation. The experimental results tested on a set of numerical benchmark functions show that GACR algorithm can outperform ACR algorithm in most of the experiments

Keywords: artificial chemical reaction optimization algorithm; Numerical optimization.

1. Introduction

Artificial chemical reaction (ACR) optimization algorithm, which was proposed by Bilal Alatas in 2011 [1], is a population-based heuristics optimization technique inspired from types and occurring of chemical reactions. But it is well known that exploitation is necessary for a population-based optimization algorithm.Several studies have shown that applying the global best (gbest) solution to guide the search of new candidate solutions can improve the exploitation of heuristics algorithms significantly[2].We modify the solution search equation by applying the global best (gbest) solution to guide the search of new candidate solutions in order to improve the exploitation, We define the ACR algorithm using the modified solution search equation as Gbest-guided ACR (GACR) algorithm.

2. Background information and overview of ACR optimization algorithm

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The algorithm proposed in this paper addresses optimization problems in the continuous domain of the form

$$\min_{x\in M} f(x) \tag{1}$$

where $x \in R^n$ *,and* $M = \{x \in R^n | l_i \le x_i \le u_i, i = 1,2,\cdots,n\} \subseteq R^n$ *,with* l_i *and* u_i *being the lower and upper bounds of* x_i *, respectively.*

The framework of ACR algorithm [1] can be described as the following four steps:

*Step 1: Setting the initial reactants and e*valuation.

Step 2: Applying chemical reactions.

Step 3: Reactants update.

Step 4: Termination criterion check.

3. Gbest-guided ACR (GACR) algorithm

As well known that exploitation is necessary for the population-based optimization algorithms,such as genetic algorithm[3], differential evolution algorithm[4], and so on. There is one important detail that should be pointed out for the framework of ACR algorithm described above. the update process used in step2 and step3 includes five types of chemical reactions: Bimolecular reactions, Synthesis reaction, Displacement reaction, Redox2 reaction and Monomolecular reactions.In synthesis reaction,a new reactant is obtained as $R = (r_1,\cdots,r_i,\cdots,r_n)$ where

$$r_i = r_i^1 + \lambda_i (r_i^2 - r_i^1) \tag{2}$$

Where λ_i is a randomly chosen value in the interval [-0.25, 1.25], $R_1 = (r_1^1,\cdots,r_n^1)$ and $R_2 = (r_1^2,\cdots,r_n^2)$ are two reactants.In displacement reaction, two new reactants are obtained as

$R_k = (r_1^k,\cdots,r_i^k,\cdots,r_n^k), k = 1,2$,where

$$r_i^1 = \lambda_t r_i^1 + (1 - \lambda_t r_i^2), r_i^2 = \lambda_t r_i^2 + (1 - \lambda_t r_i^1) \tag{3}$$

where $\lambda_t \in [0,1]$ and $\lambda_{t+1} = 2.3(\lambda_t)^{2\sin(\pi\lambda_t)}$

According to the solution search equation of ACR algorithm described by Eq. (2), the new candidate reactant is generated by moving the old reactant towards (or away from) another reactant selected from the population. However, the probability that the selected reactant is a good reactant is the same as that the selected reactant is a bad one, so the new candidate reactant is not promising to be a reactant better than the previous one. On the other hand, in Eq. (3), the coefficient λ is chaotic. therefore, the solution search dominated by Eqs. (2)and (3) is good at exploration but poor at exploitation. In order to improve the exploitation, we modify the solution search equation described by Eqs. (2) and (3) as follows

$$r_i = r_i^1 + \lambda_t (r_i^2 - r_i^1) + \Psi_i (r_i^* - r_i^1) \tag{4}$$

$$r_i^1 = \lambda_t r_i^1 + (1 - \lambda_t r_i^2) + \Psi_i (r_i^* - r_i^1),\ r_i^2 = \lambda_t r_i^2 + (1 - \lambda_t r_i^1) + \Psi_i (r_i^* - r_i^2) \tag{5}$$

where the third term in the right-hand side of Eqs. (4) and (5) is a new added term called gbest term, r_i^* is the ith element of the global best solution, Ψ_i is a uniform random number in [0,C], where C is a nonnegative constant. According to Eqs. (4) and (5), the gbest term can drive the new candidate solution towards the global best solution.

4. Applications of GACR

4.1 Numerical test problems