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Improved Imperialist Competitive Algorithm for Constrained Optimization

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ABSTRACT: This paper introduces an improved evolutionary algorithm based on the Imperialist Competitive Algorithm. The original approach in the Imperialist Competitive Algorithm has difficulty in implement practically with the increase of the dimension of the search spaces, as the ambiguous definition of the "random angle" in the process of optimization. Compare to the original algorithm, the proposed approach based on the concept of small probability perturbation has more simplicity to be implemented, especially in solving high-dimensional optimization problems. Furthermore, the present algorithm has been extended to constrained optimization problem, using a classical penalty technique to handle constraints. Several numerical optimization examples are tested by applying the proposed algorithm, and the results show its applicability and flexibility in dealing with different types of optimization problems.

KEYWORDS: Improved Imperialist Competitive Algorithm$_1$; Constrained Optimization$_2$; Evolutionary Algorithm$_3$; Penalty Technique$_4$

I. INTRODUCTION

In general, the process of optimization leads to a better outcome we anticipate. Different methods have been proposed for solving an optimization problem. Recently, considerable researches have focused on the computer simulation of the natural evolutionary process called Evolutionary Computation (EC). The basic idea of EC originated from the concept of Natural Selection or Survival of the Fittest defined by the famous naturalist Charles Darwin. Thus the optimization is similar to the process of the preservation of favorable individual differences and variations, and the destruction of those that are injurious[1]. Based on the mechanism of natural selection and a optimization process, several techniques have been developed such as genetic algorithms (GAs)[2], evolution strategies (ESs)[3], evolutionary programming (EP)[4], collectively known as Evolutionary Algorithms (EAs)[5]. Common between these techniques are the reproduction, random variation, competition, and selection of contending individuals within some population. And EA generally consists of a population of encoded individuals manipulated by a set of operators and evaluated by some fitness function. EAs have been extensively used to solve different optimization problems[6] and in many fields[7][8][9][10].

Imperialist competitive algorithm is a new evolutionary algorithm for global optimization[11], whose motivation is to simulate the process of powerful imperialistic countries dominate the colonies with competition during the colonialism. Therefore, the algorithm is also called Colonial Competitive Algorithm (CCA). Although this algorithm occurred lately, it has been quite successful in a wide range of applications such as adaptive antenna arrays[12], intelligent recommender systems[13], optimal controller for industrial and chemical possesses[14].

However, there is a bottle-neck for the algorithm to solve high-dimensional optimization problems as the ambiguous definition of the "random angle" for more than two dimensions. In this paper, an improved algorithm based on the concept of small probability perturbation is proposed, which shows that there is no restriction on the number of optimized variables. The paper is organized as follows: In Section 2, the basic flow of the imperialist competitive algorithm is briefly reviewed. A detailed description of the improved algorithm we proposed is given In Section 3. In Section 4, a constraint handling technique is introduced to extend the algorithm to constrained optimization problem. Several test examples are adopted to validate our present algorithm in Section 5. Finally, our conclusions and some possible paths of future research are given in Section 6.

II. BRIEFLY REVIEW OF IMPERIALIST COMPETITIVE ALGORITHM

The imperialist competitive algorithm (ICA for short in the sequel) is a novel heuristic evolutionary algorithm. It initials population consist of individuals named country as the beginning of the algorithm, which is similar to other evolutionary ones, and then the population are separated to two different sorts based on their cost, and defined as imperialist and colony respectively. All the imperialists and colonies assemble to form the empires in accordance with a rule, of which the colonies are divided to the empires in proportion to the normalized cost of an imperialist defined as

$$F_n = f_n - \max_k \{f_i\} \qquad (1)$$

Where f_n is the cost of the nth imperialist.

Consequently, the numbers of colonies possessed by the corresponding empires are determined by the powers of the empires.

In each empire, the colonies need to move toward their relevant imperialist, and moving distance is random variable with uniform distribution $l \sim U(0, \delta \times D)$, where D is the distance between the moving colony and the relevant imperialist, and $\delta > 1$.

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