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Review Article

A survey on the Imperialist Competitive Algorithm metaheuristic: Implementation in engineering domain and directions for future research

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ABSTRACT

The Imperialist Competitive Algorithm (ICA), derived from the field of human social evolution, is a component of swarm intelligence theory. It was first introduced in 2007 to deal with continuous optimization problems, but recently has been extensively applied to solve discrete optimization problems. This paper reviews the underlying ideas of how ICA emerged and its application to the engineering disciplines mainly on industrial engineering. The present study is the first ever comprehensive review on ICA, which indicates a statistically significant increase in the amount of published research on this metaheuristic algorithm, especially research addressing discrete optimization problems. Future research directions and trends are also described.

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1. Introduction

The Swarm Intelligence technique has become increasingly popular during the last two decades due to its capability to find a relatively optimal solution for complex combinatorial optimization problems. It has been applied in the fields of engineering, economy, management science, industry, etc. Problems that benefit from the application of Swarm Intelligence techniques are generally very hard to solve optimally in the sense that there is no such exact algorithm for solving them in polynomial time. These optimization problems are also known as NP-hard problems.

The existing approaches to deal with NP-hard problems are roughly divided into two techniques: exact algorithms and approximate algorithms. Exact algorithms refer to the techniques such as branch and bound, branch and cut, price and cut, dynamic programming, etc., in which algorithms attempt to find an optimal solution. Alternatively, approximate algorithms are able to solve large-scale NP-hard problems in less computational time while arriving at high-quality near optimal solutions. The Swarm Intelligence technique is an approximate algorithm that incorporates a widespread range of intelligent algorithms largely inspired from natural processes, e.g., Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Genetic Algorithm (GA), and Artificial Honey Bee (AHB).

The Imperialist Competitive Algorithm (ICA), a recently developed metaheuristic introduced by Atashpaz-Gargari and Lucas [1], was inspired by socio-political behaviors. The initial work on the ICA was dedicated to the continuous optimization problems, but it is currently applied to many complex discrete combinatorial optimization problems, such as Flowshop Scheduling Problem (FSP), Assembly Line Balancing Problem (ALBP), Traveling Salesman Problem (TSP), and Facility Layout Problem (FLP).

The rest of the paper is organized as follows. Section 2 represents the behavior of socio-political evolution which is the main inspiration source of ICA. Section 3 explains the procedure of implementing ICA. Section 4 discusses about parameters of ICA and general practices in tuning these parameters for best quality solutions. Section 5 reviews applications of ICA in various engineering domains. Section 6 is dedicated to statistically analyze the literature. Advantages and disadvantages of ICA are addressed in Section 7. A comparative study among the metaheuristics is presented in Section 8. Section 9 discusses some future research opportunities to enhance ICA. Finally, the concluding remarks are given in Section 10.

2. The historical phenomenon of imperialism and colonialism

Modern colonialism started in 1870 when developed countries attempted to take over less developed countries; colonize them or influence them to extend their power. The initial steps of

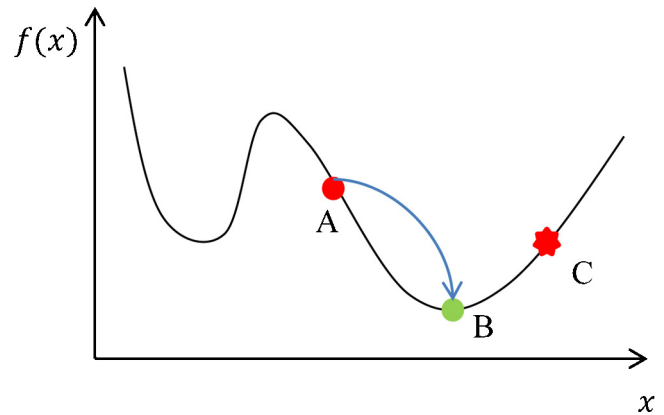


Fig. 1. Assimilating a colony toward an imperialist.

colonialism involved political-military dominance of the human and ground resources belonging to less developed countries. Developing countries subsequently competed intensively to capture more undeveloped countries or colonies. The competition among imperialists leads to political, military, and economic development of dominant countries; they were obliged to develop in order to be able to compete with other developing countries. Although colonialism resulted in well-documented atrocities, it also resulted in construction of new schools, libraries, and public transportation systems as colonialists attempted to spread their own cultural values and norms. For instance, France and the British Empire constructed many schools among their territories, including India, to spread their cultural values [2]. English was extensively taught by the British to Indian college students and gradually became the second language of India.

The colonialism phenomenon still exists, but has taken a different form. Developed countries of today attempt to control less-developed countries through direct means, such as direct legislation, or through indirect means, such as capturing their markets through exports and controlling their imports. This type of imperialism is called neocolonialism [3].

Within optimization theory, the colonialism phenomenon lifts a dominating colony out of a valley (current position) and moves it toward an imperialist peak (new minimum area). The new position of colony might even be better than the imperialist at any given time. Fig. 1 explicitly shows a colony that migrated from a minimum area to a new minimum area along the economy axis. Movement in the economy axis means that the colony improves its economy situation by taking influence of imperialist's economy. This process is called assimilation process.

Moving colony toward its imperialist could result in better solution as represented in Fig. 1. According to Fig. 1, during assimilation process, the colony from its current position (point A)

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