Ancient-inspired: a novel source of inspiration for development of metaheuristic algorithms

Sasan Harifi
Department of Computer Engineering,
Islamic Azad University,
Karaj Branch, Iran
s.harifi@kiau.ac.ir

***Abstract*—In this letter, for the first time, a novel source of inspiration for the development of metaheuristic algorithms is introduced. This source of inspiration, which is called the ancient-inspired, by combining all good features of the current source of inspirations can lead to the development of efficient algorithms. There have been numerous limitations in the ancient era, but various man-made structures indicate that limitations and lack of facilities have led to some sort of optimization. Technological breakthroughs and specific strategies in the ancient era have created ancient relics and structures some of which have remained to this day. A closer look at these ancient relics shows that the methods, strategies, and technologies used in antiquity are far more advanced and optimized than we would have imagined. While introducing this novel source of inspiration, this letter offers researchers a new classification of metaheuristic algorithms.**

Keywords—ancient-inspired ideology, metaheuristics, nature-inspired, evolutionary-based, source of inspiration, optimization.

I. INTRODUCTION

Today, the study of knowledge such as artificial intelligence and soft computing has expanded greatly. These pieces of knowledge are used to accelerate and optimize complex computing. The purpose of optimization is to find the best acceptable solution, given the constraints and needs of the problem. In other words, optimization is about finding the best solution among the situations. Optimization is used in the design and maintenance of many engineering, economic and even social systems to minimize cost or maximize profit. Due to the widespread use of optimization in different sciences, this topic has grown a lot, so that studied in mathematics, management, industries and many branches of science and even under various names such as mathematical planning and operations research are used to refer to optimization topics [1].

Currently one of the methods used for optimization is metaheuristic method. Metaheuristic algorithms are capable of achieving approximate solutions to complex problems. It should be noted that there is no specific algorithm to get the best solution for all optimization problems. Also, most algorithms cannot simultaneously provide appropriate convergence accuracy and convergence speed for various optimization problems. The main purpose of metaheuristic is to search efficiently and effectually the solution space. Also, metaheuristic is the policies and strategies that guide the search process [2].

Up to now, a variety of metaheuristic algorithms have been proposed for optimization. Various categories are also provided by the authors. In this letter, we intend to introduce a novel source of inspiration for the development of metaheuristic algorithms. This new source, called ancient-inspired, has some of the good features of existing sources of inspiration and can combine the characteristics of nature and evolution. We see many buildings and landmarks of the ancient past that remain to this day. A closer look shows them that the strategy and technology they used were far ahead of their time. So inspired by it, modern methods can be achieved.

The rest of the letter is structured as follows: Section II introduces the classification of metaheuristics. Section III describes ancient-inspired ideology. Section IV represents conclusions.

II. CLASSIFICATION OF METAHEURISTICS

Until before the introduction of the ancient-inspired, metaheuristic algorithms are divided into evolutionary-based, trajectory-based, and nature-inspired methods. Of course, we note that we have no claim to the proposed classification of existing methods. The purpose of this segmentation is to show the source of novel inspiration in the classification of metaheuristic algorithms. Figure 1 shows the presented classification.

The first category is evolutionary-based algorithms that use biological evolution such as selection, mutation, and crossover. In this type of algorithms, a population is composed of a finite number of individuals in an environment. There is a competition between these individuals who can survive in that environment based on their fitness. These worthy individuals can serve as parents for future generations. This means that new and better generations can be generated by applying crossover and mutation operators to them. The remaining members, along with the older generations, will do this again until the best generation can be reached. The population is important in evolutionary algorithms because it holds all the solutions to the problem. Usually, the population is fixed in size. Genetic Algorithm (GA)

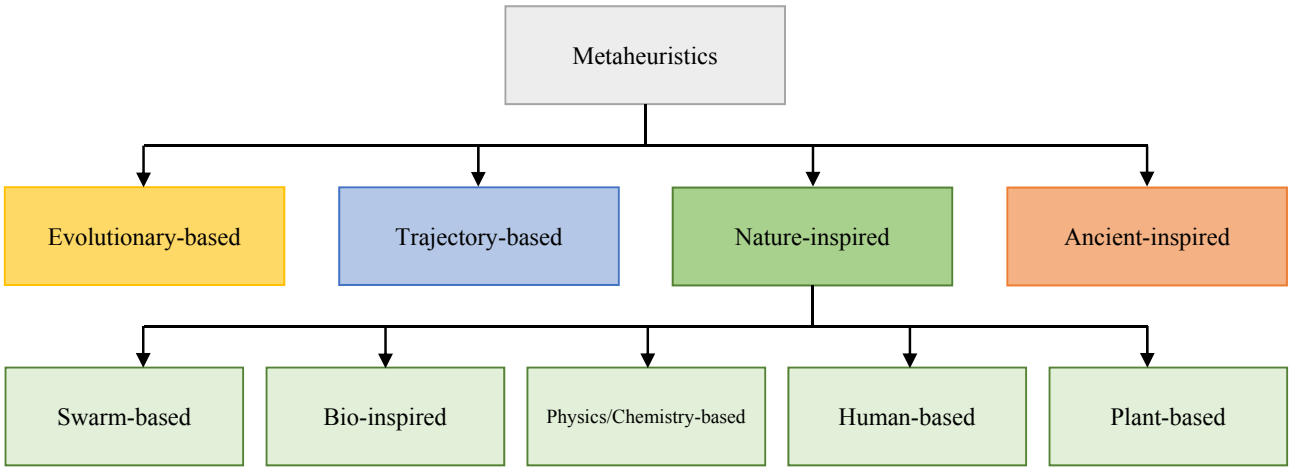

Fig 1. Classification of metaheuristics and position of new ancient-inspired category.

[3], and Differential Evolution (DE) [4] are some of the oldest and most popular evolutionary algorithms.

The second category is the trajectory-based methods. These methods are performed with repetitive routines through which they are transferred from one solution space to another space. These methods work on one solution and actually improve a single solution. The most popular trajectory-based methods are Simulated Annealing (SA) [5], Tabu Search (TS) [6].

The third category is the nature-inspired. Nature has had billions of years of opportunity to adapt, revise, and edit a variety of species. Nature has had enough time to provide a solution to any challenge. These are the solutions that human beings need to solve many of their engineering problems. Researchers are always developing algorithms that can solve a problem with the least amount of time and memory. Many real-world issues, such as the Travelling Salesman Problem (TSP) and the Knapsack problem, are ones that are always difficult to solve even for the computer in terms of time and memory. The complexity of the problem grows larger as the size and number of inputs increase. The solution to such questions is found in nature. Nature has simple and understandable laws. Nature, acting on the adaptability of phenomena to itself and always choosing the most adaptable over time, has led problem-solving techniques to move from precise and classic to intelligent. Intelligent means that is that these algorithms do not search for the whole space of a problem, and only navigate the part of the space where the existence probability of an appropriate solution is high. The collective behavior of most organisms is like an explorer in the problem space, which leads to the goal and solution. In fact, each of these organisms acts as a starting point in the problem space in its own colony. This social behavior of some creatures has been inspirational to researchers.

Nature-inspired methods are divided into five categories. These five categories are Swarm-based, Bio-inspired, Physics/Chemistry-based, Human-based, and Plant-based. Swarm-based or swarm intelligence algorithms address group behaviors and the collective intelligence of a set of beings. Swarm can be defined as an organized set of agents or entities that work together. Some of the well-known methods are Particle Swarm Optimization (PSO) [7], Ant Colony Optimization (ACO) [8], and Emperor Penguins Colony (EPC) [9]. Bio-inspired algorithms do not directly use swarm behavior. Krill Herd Algorithm (KHA) [10], and Crow Search Algorithm (CSA) [11] can be considered as bio-inspired. Physics/Chemistry-based algorithms are mostly created by imitating the laws of physics or chemistry. Chemical Reaction Optimization (CRO) [12], and Black Hole (BH) [13] are among subset. Human-based algorithm models all the individual and social behaviors of humans. Social behavior is like the chaos that occurs in society or even imperialism. Imperialist Competitive Algorithm (ICA) [14], and Cultural Algorithm (CA) [15] are popular in this subset. Plant-based simulates the growth process of plants, the scattering of plants, the expansion of the roots of plants and trees, and so on. In general, any algorithm that somehow models a plant falls into this subset. Invasive Weed Optimization (IWO) [16] is one of the algorithms in this subset.

III. Ancient-inspired Ideology

Ancient history refers to the period of the beginning of the writing and recording the events until the beginning of the post-classical period. This period lasted for almost 5000 years. There are two ways to understand this period better. The first is archeology and the second is the study of textual sources. In archeology, we interpret the behavior of past humans by examining the works of the past. Textual sources are written by ancient historians. Many events have been described by historians as textual sources.

According to information, in the ancient past, work was considered a moral virtue. It was also important to know the technical skills. The combination of work and technical skills was the key to understanding nature. This key has led to the emergence of technology in the ancient past. Studying technology and science in the ancient past is one of the most fascinating parts of antiquity. Throughout history, with the advent of civilizations, technology has improved and engineering has evolved. Many civilizations have brought technology to their peak, which is more prominent among technologies related to Egyptians, Indians, Chinese, Greeks, Romans, and Iranians. The civilizations mentioned have expanded the knowledge infrastructure to such an extent that they cannot be found elsewhere. One of the most advanced

knowledge in ancient times has been the knowledge of construction. They have always sought to reduce costs and increase productivity by using advanced construction strategies and methods. An example of these improvements can be seen in the massive structures left over.

In general, the emergence of new methods of construction has had a profound impact on the social, economic and cultural history of ancient civilizations. But that was not the only issue. Workforce management has also been one of the things that have been done well in the ancient past. Ancient-inspired ideology also observes and reflects on the above-mentioned features and seeks to understand ways of managing the project at that time. The era in which civilizations were strongly seeking ways to optimize and reduce their costs. This can be a new challenge in the development of optimization and metaheuristic algorithms. The first ancient-inspired algorithm has now been published. This algorithm that called Giza Pyramids Construction (GPC) is available in [17].

IV. Conclusions

In this letter for the first time, the ancient-inspired ideology for the development of metaheuristic methods was introduced. This novel source of inspiration seeks to pave the way for the development of efficient optimization by observing and studying the remnants of the past and understanding the ways of development and optimization strategies in the past. The goal is to create better and more efficient algorithms than existing algorithms by combining the good features of existing algorithms. Therefore, it can be said that a new challenge has begun in the development of metaheuristic algorithms.

References

[1] Harifi, S., Khalilian, M., Mohammadzadeh, J., & Ebrahimnejad, S. (2020). Optimization in solving inventory control problem using nature inspired Emperor Penguins Colony algorithm. Journal of Intelligent Manufacturing.

[2] Talbi, E. G. (2009). Metaheuristics: from design to implementation (Vol. 74). John Wiley & Sons.

[3] Holland, J. H. (1992). Genetic algorithms. Scientific american, 267(1), 66-73.

[4] Storn, R., & Price, K. (1997). Differential evolution–a simple and efficient heuristic for global optimization over continuous spaces. Journal of global optimization, 11(4), 341-359.

[5] Kirkpatrick, S., Gelatt, C. D., & Vecchi, M. P. (1983). Optimization by simulated annealing. science, 220(4598), 671-680.

[6] Glover, F., & Laguna, M. (1998). Tabu search. In Handbook of combinatorial optimization (pp. 2093-2229). Springer, Boston, MA.

[7] Kennedy, J., & Eberhart, R. (1995, November). Particle swarm optimization. In Proceedings of ICNN'95-International Conference on Neural Networks (Vol. 4, pp. 1942-1948). IEEE.

[8] Dorigo, M., Maniezzo, V., & Colorni, A. (1996). Ant system: optimization by a colony of cooperating agents. IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 26(1), 29-41.

[9] Harifi, S., Khalilian, M., Mohammadzadeh, J., & Ebrahimnejad, S. (2019). Emperor Penguins Colony: a new metaheuristic algorithm for optimization. Evolutionary Intelligence, 12(2), 211-226.

[10] Gandomi, A. H., & Alavi, A. H. (2012). Krill herd: a new bio-inspired optimization algorithm. Communications in nonlinear science and numerical simulation, 17(12), 4831-4845.

[11] Askarzadeh, A. (2016). A novel metaheuristic method for solving constrained engineering optimization problems: crow search algorithm. Computers & Structures, 169, 1-12.

[12] Lam, A. Y., & Li, V. O. (2009). Chemical-reaction-inspired metaheuristic for optimization. IEEE transactions on evolutionary computation, 14(3), 381-399.

[13] Hatamlou, A. (2013). Black hole: A new heuristic optimization approach for data clustering. Information sciences, 222, 175-184.

[14] Atashpaz-Gargari, E., & Lucas, C. (2007, September). Imperialist competitive algorithm: an algorithm for optimization inspired by imperialistic competition. In 2007 IEEE congress on evolutionary computation (pp. 4661-4667). Ieee.

[15] Reynolds, R. G. (1994, February). An introduction to cultural algorithms. In Proceedings of the third annual conference on evolutionary programming (pp. 131-139). River Edge, NJ: World Scientific.

[16] Mehrabian, Ali Reza, and Caro Lucas. "A novel numerical optimization algorithm inspired from weed colonization." Ecological informatics 1, no. 4 (2006): 355-366.

[17] Harifi, S., Mohammadzadeh, J., Khalilian, M., & Ebrahimnejad, S. (2020). Giza Pyramids Construction: an ancient-inspired metaheuristic algorithm for optimization. Evolutionary Intelligence.