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An Improved Archimedes Optimization Algorithm for Solving Optimization Problems

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***Abstract*—The Archimedes Optimization Algorithm (AOA) algorithm, a multi-agent-based metaheuristic, has garnered attention for its remarkable accuracy in real-world optimization. This research addresses solutions for the inherent limitation of original AOA, notably its susceptibility to uneven exploration and exploitation phases and its propensity to become ensnared in local optima. To overcome these limitations, we employ two strategies: the modification of the density decreasing factor and the introduction of a safe updating mechanism inspired by game theory. These enhancements are subjected to rigorous evaluation using 23 benchmark functions, and their performance is compared against that of the original AOA and other prominent algorithms, including the Multi-verse Optimization (MVO), Grasshopper Optimization Algorithm (GOA), Sine Cosine Algorithm (SCA), and Ant Lion Optimizer (ALO). The test results reveal significant improvements achieved by the newly proposed improved AOA (IAOA), surpassing the performance of the original AOA in 69% of the optimization cases among the 23 test functions. It is noteworthy that it also outperformed the other mentioned algorithms. The potential of the proposed algorithm as an effective tool for addressing real-world optimization challenges is underscored by these encouraging findings, adhering to research conventions.**

Keywords— Optimization, Meta-heuristic Algorithm, Safe Experimentation Dynamics Algorithm (SED), Archimedes Optimization Algorithm (AOA), Improved Archimedes Optimization Algorithm (IAOA).

I. INTRODUCTION

Metaheuristic optimization algorithms have become a prevalent method for tackling global optimization problems in diverse domains, including automation, mechanical engineering, and various other fields. They are favored for several significant reasons, including their flexibility, gradient-free approach, and effectiveness in avoiding local optima [1], [2]. Stochastic search procedure assists them to avoid local solutions when solving real problems which, in most case, have multi-modal objective functions. An essential feature of these algorithms is their ability to treat the optimization problem as a black box, which greatly enhances their applicability to a wide range of real-life challenges [2], [3]. In the realm of metaheuristic optimization algorithms, several noteworthy methods have gained prominence, including Genetic Algorithm (GA) [4], Particle Swarm Optimizer (PSO) [5], Cosine Algorithm (SCA)[6], Grasshopper Optimization Algorithm (GOA) [7], and Moth-Flame Optimization (MFO) [8]. All these algorithms are nature inspired and simulate some principles of biology, physics, ethology or swarm intelligence [1].

At present, most of the proposed metaheuristic optimization algorithms have different performances in solving problems due to the different phenomena simulated, so they are especially effective for a particular problem. Therefore, there is a compelling need for a metaheuristic optimization algorithm that can efficiently tackle a broader range of problems while maintaining stability and reliability. Archimedes Optimization Algorithm (AOA) is an optimization al algorithm based on the physical laws of Archimedes principle proposed by Fatma A. Hashim et al. (2020) [9]. It's a multi-agent-based swarm intelligence algorithm. This metaheuristic method is based on Archimedes' principle, which explains the law of buoyancy, particularly the relation between an object immersed in a fluid and the buoyant force applied to it. AOA can maintain the balance between the global and local search ability, and the accuracy is relatively high, so it is suitable for solving a variety of complex continuous problems. The AOA method has been successfully shown to outperform other popular metaheuristic methods such as PSO, GA, SCA and, EO (Equilibrium Optimizer)[10] in multiple benchmark tests [9]. The merits of AOA came from its simple structure and a smaller number of coefficients.

Nonetheless, like other metaheuristic methods, AOA's design has several demerits. Firstly, AOA is vulnerable to uneven exploration and exploitation phases, which decreases its search capabilities. In contrast, excessive exploitation, on the other hand, slowed the convergence process toward the global optimum solution. Thus, an adequate balance between the exploration and exploitation phases is necessary for the original AOA. Secondly, since the updated object position is exclusively dependent on its prior or best object position, there is a considerable high risk of AOA becoming stuck in the local optima and escaping the zone is difficult since the object lacks information on the best object position. Hence, it is worthwhile to thoroughly analyze and pursue these difficulties in order to deliver a better version of the AOA.

To solve the demerits of AOA stated above, an improved AOA (IAOA) is proposed in this paper. Specifically, two modifications were suggested to the original AOA. Firstly, the density decreasing factor in Equation (9) in the original AOA is modified to regulate the imbalance in the exploration and exploitation phases, which contributes to the degradation of