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Parallel SAO: Collaborative subpopulations for accelerated convergence

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Abstract: In the dynamically evolving field of collective computational optimization, modern approaches increasingly incorporate bio-inspired techniques, such as Smell Agent Optimization (SAO), to address complex, high-dimensional problems inherent to contemporary scientific and industrial applications. While these methods are distinguished by their dynamic convergence and heuristic ability to explore vast solution spaces, their growing computational complexity hinders their application in real-world, large-scale scenarios where simultaneous speed and precision are critical. To overcome this challenge, the present research advances a pioneering parallel implementation of SAO, which transcends simple workload distribution by integrating dynamic collaboration mechanisms and intelligent information dispersal among autonomous subpopulations. Concurrently, the method is enriched with innovative rules for exchanging optimal solutions between subpopulations. These rules not only prevent premature convergence to local minima but also establish a continuous flow of information that accelerates the global exploration of the solution space. Experimental validation of the proposed method demonstrated that, through optimized parameterization of the diffusion mechanisms, SAO's efficiency can exceed 70%, achieving simultaneous reductions in both the number of objective function evaluations and total execution time. This outcome holds particular significance in high-dimensional problems, where balancing computational cost and accuracy is a decisive factor. These findings not only underscore the potential of parallel SAO to deliver sustainable solutions to real-world challenges but also open new horizons in the theory and practice of collective optimization. The implications extend to domains such as large-scale data analysis, autonomous systems, and adaptive resource management, where rapid and precise optimization is paramount.

Keywords: Optimization; Smell Agent Optimization; Evolutionary techniques; Stochastic methods; Large-Scale problems

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