Sandpiper Food Search Algorithm:
A New Optimization Approach for Agents with Limited Knowledge

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Biologically Inspired Design-for-Resilience Lab

Abstract

Optimization problems in mechanical engineering drive advancements in system designs, performance enhancement, and maximizing efficiency across various applications. While conventional methods face limitations with increasingly complex problems, metaheuristic algorithms inspired by nature offer promising solutions. However, many existing algorithms such as the Firefly Algorithm, Particle Swarm Optimization, Generic Algorithm, Bath Algorithm, and Cuckoo Search lack realism in handling localized knowledge, crucial for certain real-world complex systems such as underground mining and spacecraft trajectory. To bridge this gap, we introduce the Sandpiper Food Search Algorithm, inspired by sandpipers' foraging behaviour at the beach where each agent (sandpiper) explores the problem space to find the optimal area by exploiting the local search for candidate solutions around them. Moreover, this algorithm includes the wave action that forces these birds to shift from their current solution to increase exploration of the solution space. Our evaluation was performed using four standard benchmark functions in comparison with the Firefly Algorithm as it shares similar parameterization characteristics, and its use of decreasing light brightness with distance between fireflies mirrors the limitation of knowledge imposed by the visibility radius in sandpipers. Our research reveals that the Sandpiper Food Search Algorithm has outperformed the Firefly Algorithm in three out of the four functions with at least 3% improvement in mean best solution and on average 38% more reliable at finding a solution at least 95% of the optimal.

Research Question

How can we use sandpiper food search behavior as a new inspiration for optimization algorithms, where can we apply them, and how does it compare with other algorithms?

Purpose

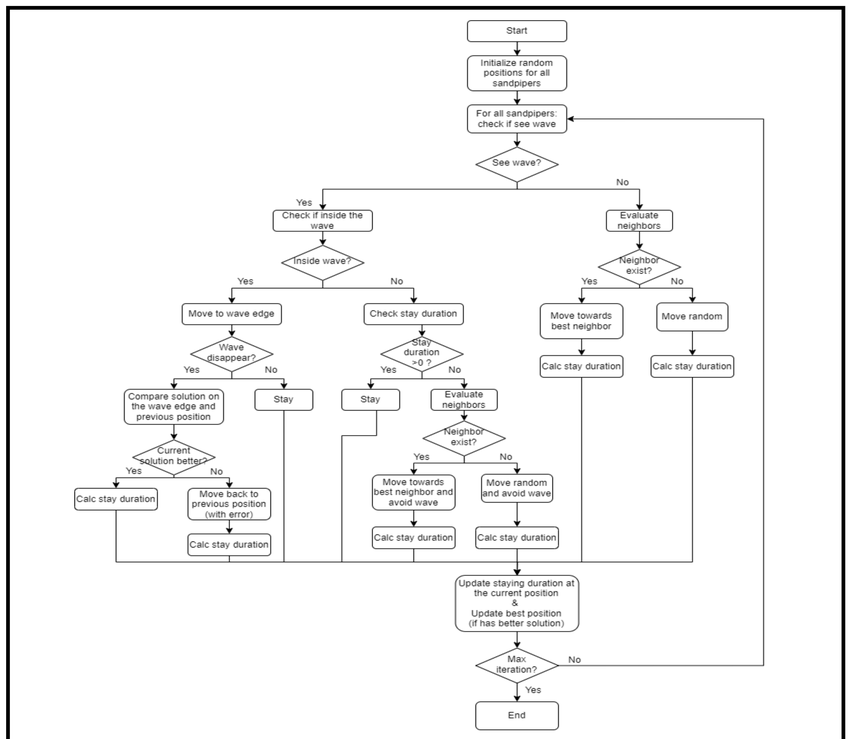
- Conceptual design of the new Sandpiper Food Search Algorithm with agents of limited knowledge
- Performance of Sandpiper Food Search Algorithm compared to Firefly Algorithm across 4 benchmark functions

Hypothesis

We hypothesize that the Sandpiper Food Search Algorithm will perform better than the Firefly Algorithm across Ackley, Griewank, Holder Table, and Rastrigin benchmark functions.

Figure 1. A flock of sandpipers at the beach

Algorithm and Simulation Overview



The algorithm uses staying duration information that is only shared across the neighbors and is relative to each agent, differing in scale within the swarm due to the relative information. This approach limits the sharing of global knowledge within the swarm which most algorithm has.

Figure 2. Sandpiper Food Search Algorithm Flowchart

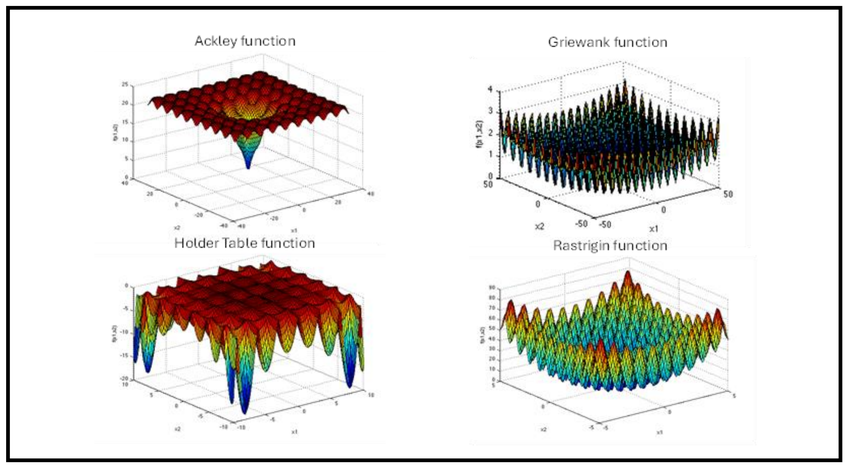


Figure 3. Benchmark functions used plotted in 3D (reproduced from [1])

Results

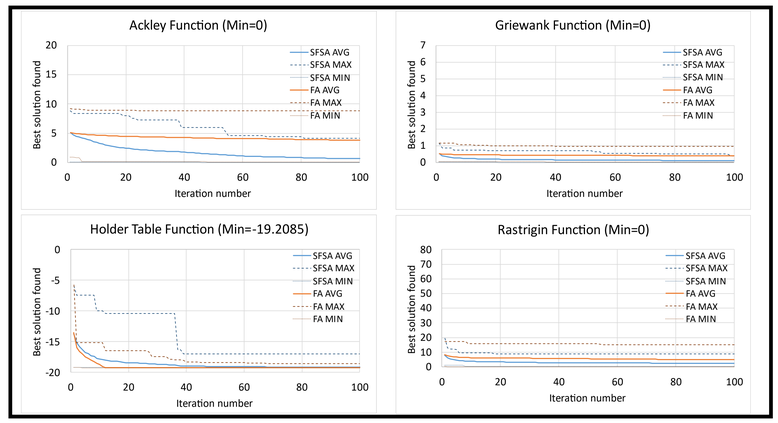


Figure 4. Results of SFSA and FA over iterations in four benchmark functions

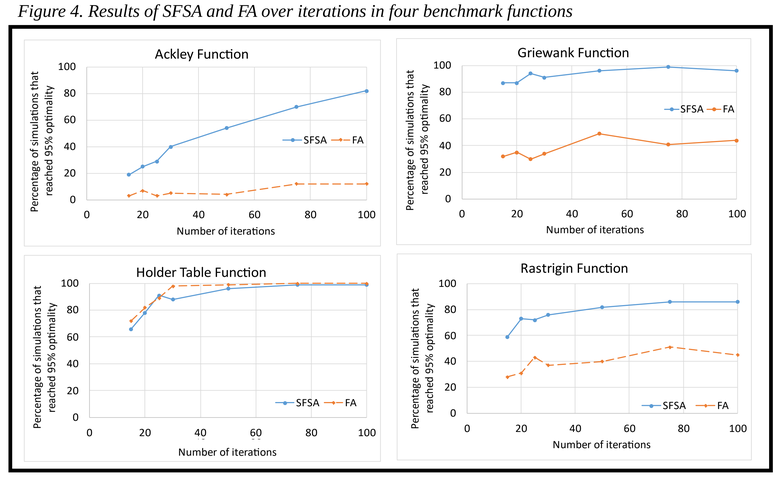


Figure 5. Comparison of SFSA and FA in four benchmark functions

Conclusion

- Simulation results show that the proposed optimization algorithm (SFSA) outperforms the FA by a minimum of 3% and is on average 38% more reliable on 3 of 4 benchmark functions evaluated.
- The Sandpiper Food Search Algorithm may be a feasible optimization algorithm that can be translatable to a real-world problem

Future Work

- Application of the algorithm to a BID4R Roving Swarm Test Platform
- Parameter tuning, high-dimensionality tests, and comparison against other algorithms
- ASME JCISE Journal Paper

Citations

[1] S. Surjanovic and D. Bingham, "Virtual library of simulation experiments:," Optimization Test Functions and Datasets, https://www.sfu.ca/~ssurjano/optimization.html.