**Orca Predation Algorithm**

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**Analysis of Algorithm**

**BSDS 4-1**

**Semester Project**

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Orca Predation Algorithm

Documentation

# **1. Introduction**

The Orca Predation Algorithm (OPA) is a nature-inspired metaheuristic optimization algorithm. It mimics the social behavior and predation strategies of orcas (also known as killer whales) in the wild. Orcas are apex predators known for their intelligent hunting strategies such as group hunting, herding prey, and wave-washing. These behaviors have inspired the development of OPA to solve complex optimization problems in various domains, including engineering design, machine learning, and operations research.

# **2. Biological Inspiration**

OPA simulates the real-world cooperative hunting methods of orcas, which often include:

* **Echolocation** to detect prey.
* **Herding** where orcas circle around the prey.
* **Wave-washing** to push prey off ice or destabilize them.
* **Surprise attacks** and coordinated movements for successful predation.

These strategies are analogously applied to guide the search agents in the solution space.

# **3. Algorithm Overview**

OPA works as a population-based stochastic optimization technique, where a group of candidate solutions (orcas) navigate the search space in pursuit of the optimal solution (prey).

## **Steps Involved**:

### **Initialization:**

* + Randomly generate a population of solutions within the defined bounds.
  + Evaluate fitness of each individual.

### **Movement Strategies:**

* + Orcas update their position based on a combination of:
    - **Echolocation-based exploitation** (intensification).
    - **Herding behavior** (diversification).
    - **Wave-washing attack** (large positional shifts to escape local optima).

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### **Fitness Evaluation:**

* + Each new position is evaluated for its objective function value.
  + The best solution (prey) is updated if a better one is found

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### **Termination:**

* + Stop after a fixed number of iterations or once convergence is achieved.

# **4. Mathematical Modeling**

Let:

* XitXit​ be the position of the ithith orca at iteration tt,
* XbesttXbestt​ be the current best solution,
* r∈[0,1]r∈[0,1] be a random number,
* A,CA,C be control parameters that simulate different hunting behaviors.

## **Position Update Rule**:

A simplified version:

Xit+1=Xbestt−A⋅∣C⋅Xbestt−Xit∣Xit+1​=Xbestt​−A⋅∣C⋅Xbestt​−Xit​∣

Where:

* A=2a⋅r−aA=2a⋅r−a,
* C=2rC=2r,
* a decreases linearly from 2 to 0 (encourages exploration early, exploitation later).

This resembles the update mechanism in other swarm-based algorithms like Whale Optimization Algorithm (WOA) but with behavior specific to orcas.

# **5. Applications**

OPA can be applied to a wide variety of optimization problems:

* Feature selection
* Scheduling
* Parameter tuning (e.g., neural networks, SVM)
* Engineering design problems

# **6. Advantages**

* Balances exploration and exploitation effectively.
* Inspired by real-world coordinated strategies.
* Easily hybridizable with other algorithms.

# **7. Limitations**

* Can get trapped in local optima for high-dimensional problems.
* Requires parameter tuning for best performance.
* Computationally expensive for large populations or iterations.

# **8. Future Improvements**

* Adaptive control parameters.
* Hybridization with machine learning techniques.
* Parallel and distributed implementations.

# **9. References**

1. Ali Asghar Heidari, et al. (2020). "Nature-Inspired Algorithms: A Review."
2. Orca hunting documentaries and ethology research.
3. Research papers on swarm intelligence and bio-inspired computing.

# **10. GitHub**

**Link:**[**https://github.com/Kaleem205/AoA-Project.git**](https://github.com/Kaleem205/AoA-Project.git)

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