# Cuckoo Search (CS)Project Report


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PROJECT CUCKOO SERACH

SUBJECT ANALYSIS OF ALGORITHM

## TABLE OF CONTENTS


1. Introduction
2. Problem Statement
3. Algorithm Overview
4. Methodology
    4.1. Problem Formulation
    4.2. Parameter Initialization
    4.3. Fitness Function
    4.4. Movement Strategy
    4.5. Termination Criteria
    4.6. Performance Evaluation
5. Code Implementation
6. Complexity Analysis
7. Real-World Application: Drone Delivery Optimization
8. Limitations
9. Conclusion
10. References
11. GitHub Link

# 1. INTRODUCTION

Cuckoo Search (CS) is a nature-inspired metaheuristic algorithm developed by Xin-She Yang and Suash Deb in 2009. It is based on the brood parasitism behavior of certain cuckoo species, combined with the Lévy flight behavior of birds. The algorithm mimics how cuckoos lay their eggs in the nests of other host birds, and how some hosts discard foreign eggs. CS balances exploration and exploitation through random walks and replacement of poorly performing solutions, making it effective for solving both continuous and discrete optimization problems.

# 2. PROBLEM STATEMENT

With the increasing use of autonomous drones for delivery services, it is essential to find efficient and adaptive path planning algorithms. The aim of this project is to optimize the path of a drone from its current position to a predefined delivery location. The objective is to minimize travel distance and computation time. The Cuckoo Search algorithm is applied here to simulate the adaptive pathfinding behavior of the drone.

# 3. ALGORITHM OVERVIEW

In the Cuckoo Search algorithm, each “cuckoo” represents a candidate solution. The algorithm operates by replacing worse solutions in the population with potentially better solutions generated by Lévy flights.

Main concepts:

- Each cuckoo lays one egg (a new solution) at a time.

- The best nests with high-quality solutions are carried over.

- A fraction (pa) of the worst nests are abandoned and replaced.

Key parameters:

- Number of nests (population size)

- Discovery rate of alien eggs (pa)

- Lévy flight step size

# 4. METHODOLOGY

4.1. Problem Formulation

Objective: Minimize the Euclidean distance from a drone’s position to a delivery point at (7, 5).

4.2. Parameter Initialization

- Total nests (solutions): 20

- Iterations: 100

- Discovery rate (pa): 0.25

- Initial positions: Randomly generated in a 10x10 grid

- Step size: Controlled using Lévy flight

4.3. Fitness Function

Fitness = $\sqrt{(x - 7)^2 + (y - 5)^2}$

Where (x, y) is the drone's current location.

4.4. Movement Strategy

- A new position is generated for each cuckoo using Lévy flight.

- If the new solution has better fitness than a randomly chosen nest, it replaces it.

- A fraction of the worst nests are replaced randomly.

4.5. Termination Criteria

The algorithm runs for a fixed 100 iterations or stops early if no improvement is observed over successive generations.

4.6. Performance Evaluation

Performance is evaluated by comparing initial and final distances to the target. The convergence trend is plotted to assess efficiency.

## 5. CODE IMPLEMENTATION

The algorithm is implemented in C++. Key components include:

- A `Nest` class representing each solution with coordinates and fitness.

- A `levyFlight()` function for movement generation.

- Main loop for iterative optimization and replacement of nests.

## 6. COMPLEXITY ANALYSIS

Time Complexity: $O(N \times I)$

- $N$ = number of nests

- $I$ = number of iterations

Space Complexity: $O(N)$

Only positions and fitness values are stored. This makes CS suitable for real-time and embedded applications.

## 7. REAL-WORLD APPLICATION: DRONE DELIVERY OPTIMIZATION

Drones operating in dynamic environments need adaptive algorithms. CS enables:

- Efficient rerouting in changing weather or traffic conditions

- Reduced computational load

- Fast convergence for real-time adjustments

Its simplicity and flexibility make CS useful for smart delivery systems and autonomous robotic navigation.

## 8. LIMITATIONS

- Current implementation is 2D only

- Obstacles and real-time dynamic constraints are not modeled

- Fixed destination point; not suitable for multi-target missions without modification

- Step size control in Lévy flight can be sensitive

## 9. CONCLUSION

Cuckoo Search is a powerful and elegant algorithm for optimization problems. In this project, it demonstrated effectiveness in guiding drones toward a delivery point by simulating natural selection and Lévy-based search. Even with a basic version, the algorithm showed clear improvements in pathfinding. It provides a promising basis for more advanced autonomous delivery applications.

## 10. REFERENCES

- Yang, X. S., & Deb, S. (2009). Cuckoo Search via Lévy Flights. World Congress on Nature & Biologically Inspired Computing (NaBIC), 210-214.

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