



# Cuckoo Search

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# Cuckoo Breeding Behavior

- Quite a number of cuckoo species engage in obligate brood parasitism by laying their eggs in the nests of other host birds (often other species)
- Specialized in mimicry in color and pattern of the eggs of a few chosen host species
- Parasitic cuckoos often choose a nest where the host bird just laid its own eggs
- In general, the cuckoo eggs hatch slightly earlier than their host eggs. Once the first cuckoo chick is hatched, the first instinct action it will take is to evict the host eggs by blindly propelling the eggs out of the nest



# Cuckoo Search (CS) Dynamics

There are several parameters in CS. Apart from the population size  $n$ , there are switching probability  $p_a$ , step-size scaling factor  $\alpha$ , and the Lévy exponent  $\lambda$ . However, the key parameters are  $p_a$  and  $n$  because we can take  $\alpha$  and  $\lambda$  as constants. By varying their values, we found that we can set  $\lambda = 1.5$  and  $\alpha = 0.01$  for most problems.

Various studies have shown that flight behavior of many animals and insects has demonstrated the typical characteristics of Lévy flights with power law-like characteristics

Isotropic random walks (diffusion)  
Gaussian distribution

$$p(s) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{(s-\mu)^2}{2\sigma^2}\right],$$

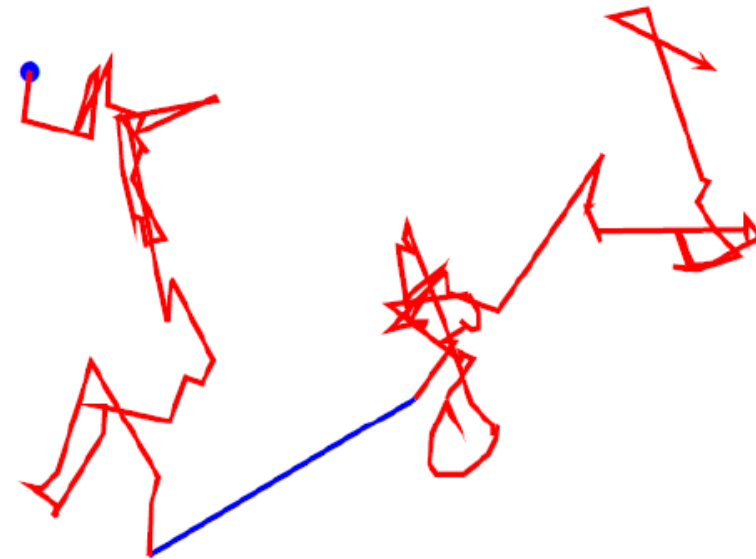
Lévy flights (superdiffusion)  
Lévy distribution

$$L(s, \lambda) \sim \frac{1}{\pi} \int_0^\infty \cos(ts) e^{-\alpha t^\lambda} dt.$$

Typical paths of  $t = 50$  consecutive steps of random walks



Diffusion distance:  $d(t) \sim \sqrt{t}$



$d(t) \sim t^{(3-\lambda)/2}$  (for  $1 \leq \lambda \leq 2$ )

## Cuckoo Search via Lévy Flights

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Objective function  $f(\mathbf{x})$ ,  $\mathbf{x} = (x_1, \dots, x_d)^T$

Generate initial population of  $n$  host nests  $\mathbf{x}_i$

**while** ( $t < \text{MaxGeneration}$ ) or (stop criterion)

    Get a cuckoo randomly

    Generate a solution by Lévy flights [e.g., Eq.(9.2)]

    Evaluate its solution quality or objective value  $f_i$

    Choose a nest among  $n$  (say,  $j$ ) randomly

**if** ( $f_i < f_j$ ),

        Replace  $j$  by the new solution  $i$

**end**

    A fraction ( $p_a$ ) of worse nests are abandoned

    New nests/solutions are built/generated by Eq.(9.1)

    Keep best solutions (or nests with quality solutions)

    Rank the solutions and find the current best

    Update  $t \leftarrow t + 1$

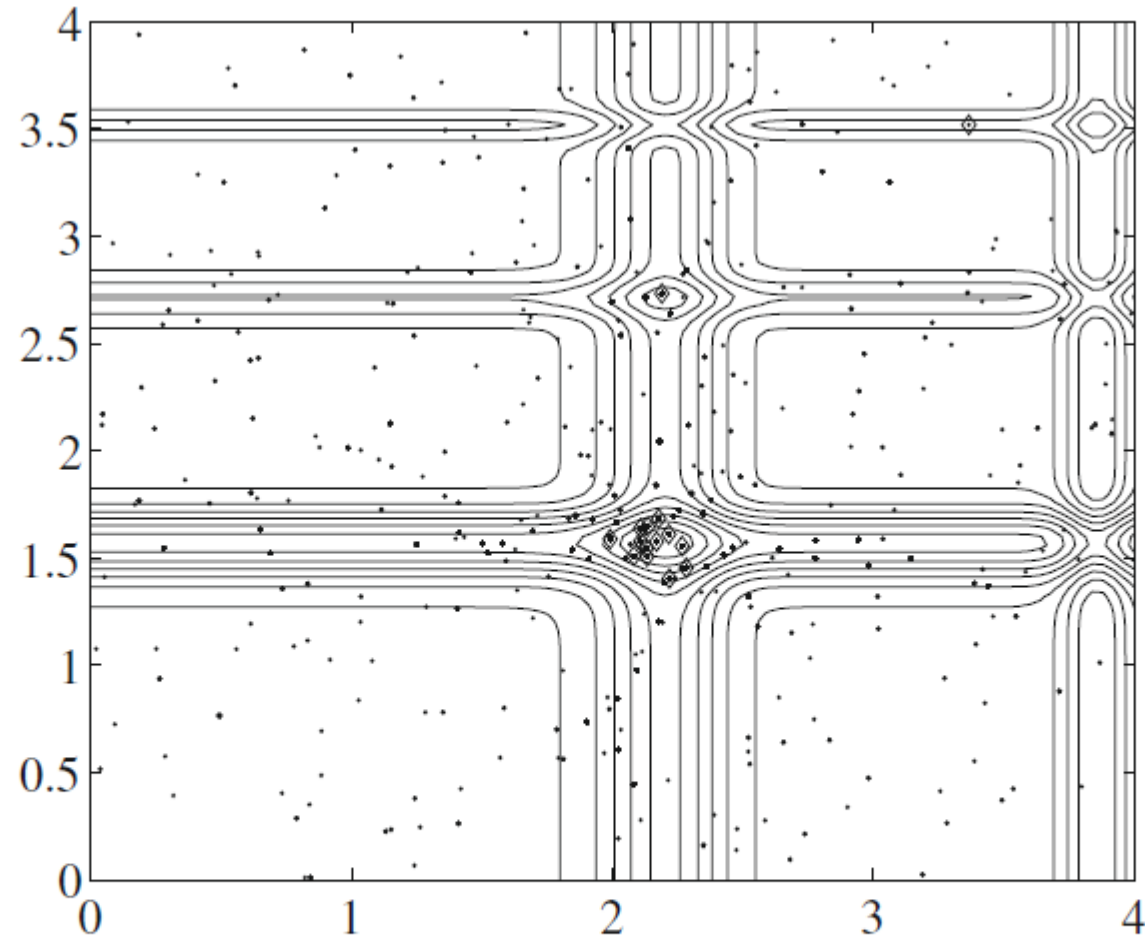
**end while**

Postprocess results and visualization

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For the key parameters, we have also tried to vary the number of host nests (or the population size  $n$ ) and the probability  $p_a$ . We have used  $n = 5, 10, 15, 20, 30, 40, 50, 100, 150, 250, 500$  and  $p_a = 0, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5$ . From our simulations, we found that  $n = 15$  to  $40$  and  $p_a = 0.25$  are sufficient for most optimization problems. Results and analysis also imply that the convergence rate, to some extent, is not sensitive to the parameters used. This means that the fine adjustment is not needed for any given problems.

**Bivariate Michalewicz function:** 
$$f(x, y) = -\sin(x) \sin^{2m}\left(\frac{x^2}{\pi}\right) - \sin(y) \sin^{2m}\left(\frac{2y^2}{\pi}\right)$$



**Figure 9.2** Search paths of nests using CS. The final locations of the nests are marked with ◊ in the figure.

# ***Variants of Cuckoo Search***

- *Quantum cuckoo search (QCS)*. A variant of CS by adding quantum behavior to the algorithm.
- *Discrete cuckoo search (DCS)*.
- *Multi-objective cuckoo search (MOCS)*.
- *Discrete multi-objective cuckoo search (DMOCS)*.
- *Hybrid cuckoo search (HCS)*.

# What is the next algorithm?

- **Swarm Intelligence**

- Dolphin echolocation
- Egyptian vulture
- The fish swarm/school algorithm
- The great salmon run algorithm
- The group search optimizer
- Monkey search
- The shuffled frog-leaping algorithm
- Wolf search

- **Non-Swarm Intelligence**

- Big bang, big crunch
- Bacterial foraging algorithm
- The black-hole algorithm
- Charged system search
- Gravitational search
- The galaxy-based search algorithm
- The intelligent water drop algorithm
- Invasive weed optimization
- The water-cycle algorithm
- Spiral optimization

*But what about the whales???*

# Questions?



Looks like he went a little too cuckoo for cocoa puffs...