

Scientific Research Group in Egypt (SRGE)

Cuckoo search algorithm

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Outline

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Cuckoo search algorithm (History and main idea)

- A method of global optimization based on the behavior of cuckoos was proposed by Yang & Deb (2009).

- The original "cuckoo search (CS) algorithm" is based on the idea of the following :-

➢ How cuckoos lay their eggs in the host nests.

➢ How, if not detected and destroyed, the eggs are hatched to chicks by the hosts.

➢ How a search algorithm based on such a scheme can be used to find the global optimum of a function.

Behavior of Cuckoo breeding

•The CS was inspired by the obligate brood parasitism of some cuckoo species by laying their eggs in the nests of host birds.

•Some cuckoos have evolved in such a way that female parasitic cuckoos can imitate the colors and patterns of the eggs of a few chosen host species.

•This reduces the probability of the eggs being abandoned and, therefore, increases their reproductivity .

Behavior of Cuckoo breeding (Cont.)

- If host birds discover the eggs are not their own, they will either throw them away or simply abandon their nests and build new ones.

- 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.

Behavior of Cuckoo breeding (Cont.)

•Once the first cuckoo chick is hatched, his first instinct action is to evict the host eggs by blindly propelling the eggs out of the nest.

•This action results in increasing the cuckoo chick's share of food provided by its host bird .

•Moreover, studies show that a cuckoo chick can imitate the call of host chicks to gain access to more feeding opportunity.

Characteristics of Cuckoo search

•Each egg in a nest represents a solution, and a cuckoo egg represents a new solution.

•The aim is to employ the new and potentially better solutions (cuckoos) to replace not-so-good solutions in the nests.

• In the simplest form, each nest has one egg.

•The algorithm can be extended to more complicated cases in which each nest has multiple eggs representing a set of solutions

Characteristics of Cuckoo search (cont)

The CS is based on three idealized rules:

- Each cuckoo lays one egg at a time, and dumps it in a randomly chosen nest

- The best nests with high quality of eggs (solutions) will carry over to the next generations

- The number of available host nests is fixed, and a host can discover an alien egg with probability $p \in [0,1]$.

- In this case, the host bird can either throw the egg away or abandon the nest to build a completely new nest in a new location.

Lèvy Flights

•In nature, animals search for food in a random or quasi-random manner.

•Generally, the foraging path of an animal is effectively a random walk because the next move is based on both the current location/state and the transition probability to the next location.

•The chosen direction implicitly depends on a probability, which can be modeled mathematically.

Lèvy Flights (Cont.)

- A Lévy flight is a random walk in which the step-lengths are distributed according to a heavy-tailed probability distribution.

- After a large number of steps, the distance from the origin of the random walk tends to a stable distribution.

Cuckoo search Algorithm

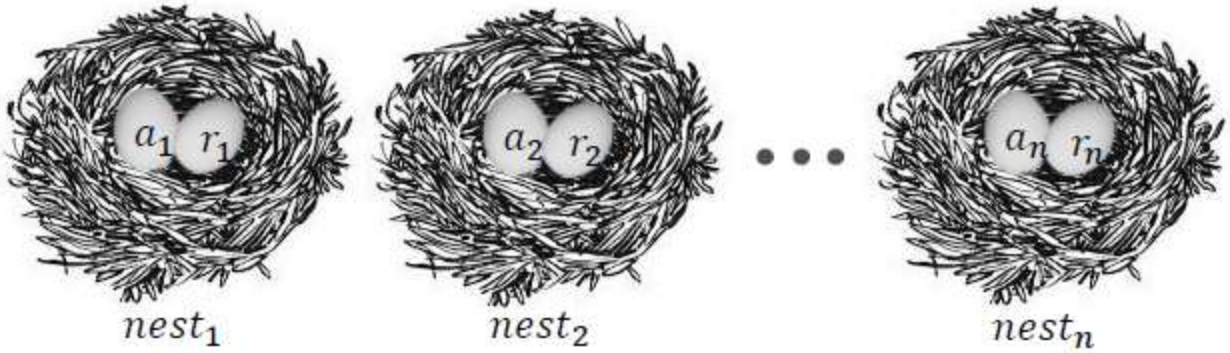
Algorithm 1 Cuckoo search algorithm

1: Set the initial value of the host nest size n, probability $p_a \in [0, 1]$ and maximum number of iterations Max_{itr}.
2: Set $t := 0$. {Counter initialization}.
3: **for** $(i = 1 : i \leq n)$ **do**
4: Generate initial population of n host $x_i^{(t)}$. {n is the population size}.
5: Evaluate the fitness function $f(x_i^{(t)})$.
6: **end for**
7: **repeat**
8: Generate a new solution (Cuckoo) $x_i^{(t+1)}$ randomly by Lévy flight.
9: Evaluate the fitness function of a solution $x_i^{(t+1)}$ $f(x_i^{(t+1)})$
10: Choose a nest x_j among n solutions randomly.
11: **if** $(f(x_i^{(t+1)}) > f(x_j^{(t)}))$ **then**
12: Replace the solution x_j with the solution $x_i^{(t+1)}$
13: **end if**
14: Abandon a fraction p_a of worse nests.
15: Build new nests at new locations using Lévy flight a fraction p_a of worse nests
16: Keep the best solutions (nests with quality solutions)
17: Rank the solutions and find the current best solution
18: Set $t = t + 1$. {Iteration counter increasing}.
19: **until** $(t < Max_{itr})$. {Termination criteria satisfied}.
20: Produce the best solution.

Cuckoo search Algorithm (Cont)

The following steps describe the main concepts of Cuckoo search algorithm

Step1. Generate initial population of n host nests.



(*ai*,*ri*) : a candidate for optimal parameters

Cuckoo search Algorithm (Cont)

Step2. Lay the egg (ak',bk') in the k nest.

- K nest is randomly selected.
- Cuckoo's egg is very similar to host egg.

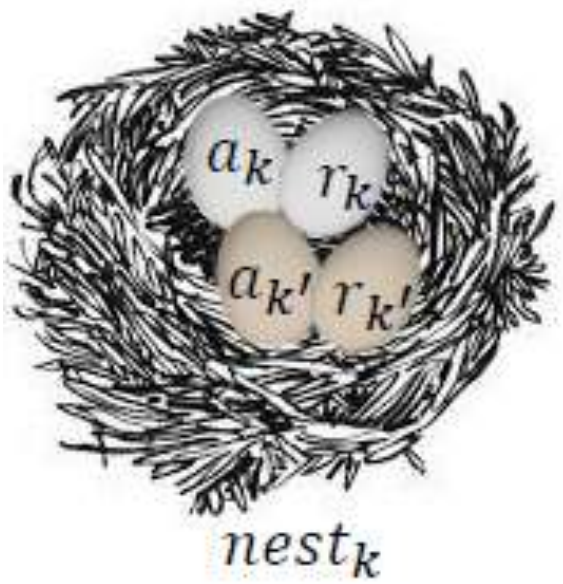
Where

$$ak' = ak + Randomwalk(\text{Lèvy flight})ak$$
$$rk' = rk + Randomwalk(\text{Lèvy flight})rk$$

Cuckoo search Algorithm (Cont)

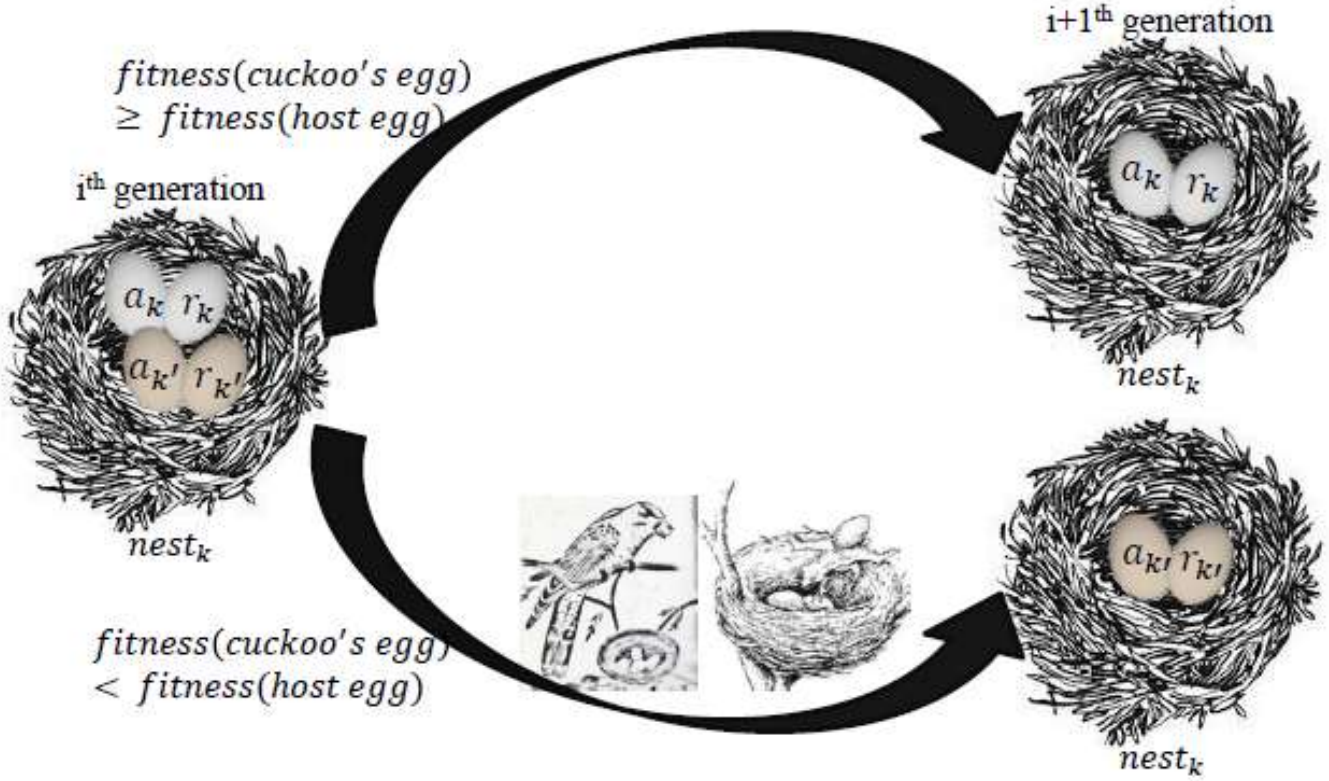
Step3. Compare the fitness of cuckoo's egg with the fitness of the host egg.

Root Mean Square Error (RMSE)



Cuckoo search Algorithm (Cont)

Step4. If the fitness of cuckoo's egg is better than host egg, replace the egg in nest k by cuckoo's egg.



Cuckoo search Algorithm (Cont)

Step5. If host bird notice it, the nest is abandoned and new one is built. (p <0.25) (to avoid local optimization)

Iterate **steps 2 to 5** until termination criterion satisfied

Application of the CS Algorithm

- Engineering optimization problems
- NP hard combinatorial optimization problems
- Data fusion in wireless sensor networks
- Nanoelectronic technology based operation-amplifier
- (OP-AMP)
- Train neural network
- Manufacturing scheduling
- Nurse scheduling problem

References

Xin-She Yang, Nature-Inspired Optimization Algorithms, Elsevier, (2014).

Xin-She Yang, Cuckoo Search and Firefly Algorithm: Theory and Applications, Springer, (2013).

Xin-She Yang and Suash Deb, Multiobjective cuckoo search for design optimization, Computers & Operations Research, 40(6), 1616–1624 (2013).

Some contents are taken from the original slides in
The Use of Cuckoo Search in Estimating the Parameters of Software Reliability Growth Models 2013. 8. 7 Taehyoun Kim

Thank you

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