SCT UNIT-5 - SCT

SOFT COMPUTING TECHNIQUES

UNIT-5

UNIT -V:

Swarm Intelligent system: Introduction to swarm intelligence, back ground, Ant colony system, working of ant colony optimization, Particle swarm intelligent systems, Artificial bee colony system, cuckoo search algorithm..

Ant colony system

Algorithms are processes or optimized solutions for any complex problems. There is always a principle behind any algorithm design. Sometimes, these algorithms are designed from natural laws and events, and evolutionary algorithms are the example of these algorithms.

This algorithm uses natural events and behavior as it is to get the low-cost and best possible solution to a complex problem.

There are a lot of algorithms based on natural behavior, and they are called metaheuristics. Metaheuristics are made of two words: meta, which means one level above, and heuristics, which means to find.

Particle Swarm Optimization and **Ant Colony Optimization** are examples of these swarm intelligence algorithms. The objective of the swarm intelligence algorithms is to get the optimal solution from the behavior of insects, ants, bees, etc.

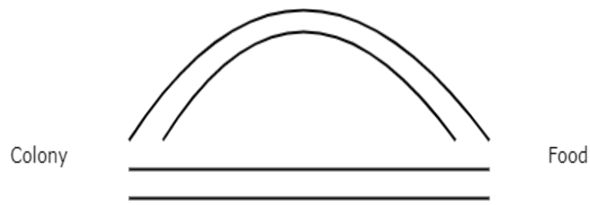
Principle of Ant Colony Optimization

This technique is derived from the behavior of ant colonies. Ants are social insects that live in groups or colonies instead of living individually. For communication, they use pheromones. Pheromones are the chemicals secreted by the ants on the soil, and ants from the same colony can smell them and follow the instructions.

To get the food, ants use the shortest path available from the food source to the colony. Now ants going for the food secret the pheromone and other ants follow this pheromone to follow the shortest route. Since more ants use the shortest route so the concentration of the pheromone increase and the rate of evaporation of pheromone to other paths will be decreased, so these are the two major factors to determine the shortest path from the food source to the colony.

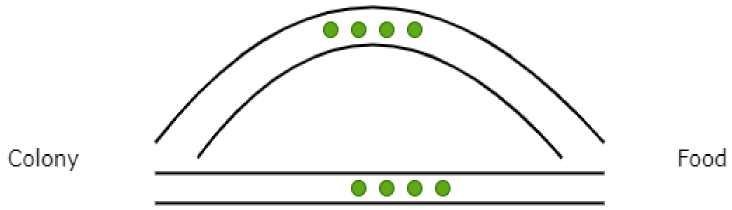
We can understand it by following steps:

Stage 1:



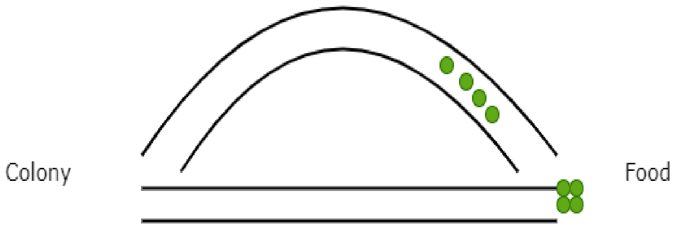
In this stage, there is no pheromone in the path, and there are empty paths from food to the ant colony.

Stage2:



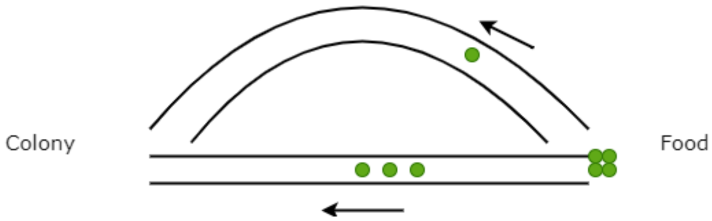
In this stage, ants are divided into two groups following two different paths with a probability of 0.5. So we have four ants on the longer path and four on the shorter path.

Stage 3:



Now, the ants which follow the shorter path will react to the food first, and then the pheromone concentration will be higher on this path as more ants from the colony will follow the shorter path.

Stage 4:



Now more ants will return from the shortest path, and the concentration of pheromones will be higher. Also, the rate of evaporation from the longer path will be higher as fewer ants are using that path. Now more ants from the colony will use the shortest path.

Algorithm Design

- Now the above behavior of the ants can be used to design the algorithm to find the shortest path. We can consider the ant colony and food source as the node or vertex of the graph and the path as the edges to these vertices. Now the pheromone concentration can be assumed as the weight associated with each path.
- Let's suppose there are only two paths which are P1 and P2. C1 and C2 are the weight or the pheromone concentration along the path, respectively.
- So we can represent it as graph G(V, E) where V represents the Vertex and E represents the Edge of the graph.
- Initially, for the ith path, the probability of choosing is:

- Introduction to Ant Colony Optimization
- If C1 > C2, then the probability of choosing path 1 is more than path 2. If C1 < C2, then Path 2 will be more favorable.
- For the return path, the length of the path and the rate of evaporation of the pheromone are the two factors.

Particle swarm intelligent systems

Particle Swarm Optimization characterized into the domain of Artificial Intelligence. The term 'Artificial Intelligence' or 'Artificial Life' refers to the theory of simulating human behavior through computation. It involves designing such computer systems which are able to execute tasks which require human intelligence. For eg, earlier only humans had the power to recognize the speech of a person. But now, speech recognition is a common feature of any digital device. This has become possible through artificial intelligence. Other examples of human intelligence may include decision making, language translation, and visual perception etc. There are various techniques which make it possible. These techniques to implement artificial intelligence into computers are popularly known as approaches of artificial intelligence'.

These techniques are designed basis two categories:

- The first study includes how biological phenomena can be studies using computation.
- The second one shows how biological phenomena can help understand computation problems. While studying the PSO Technique, we deal with in the second category.

There are three approaches of the artificial intelligence:

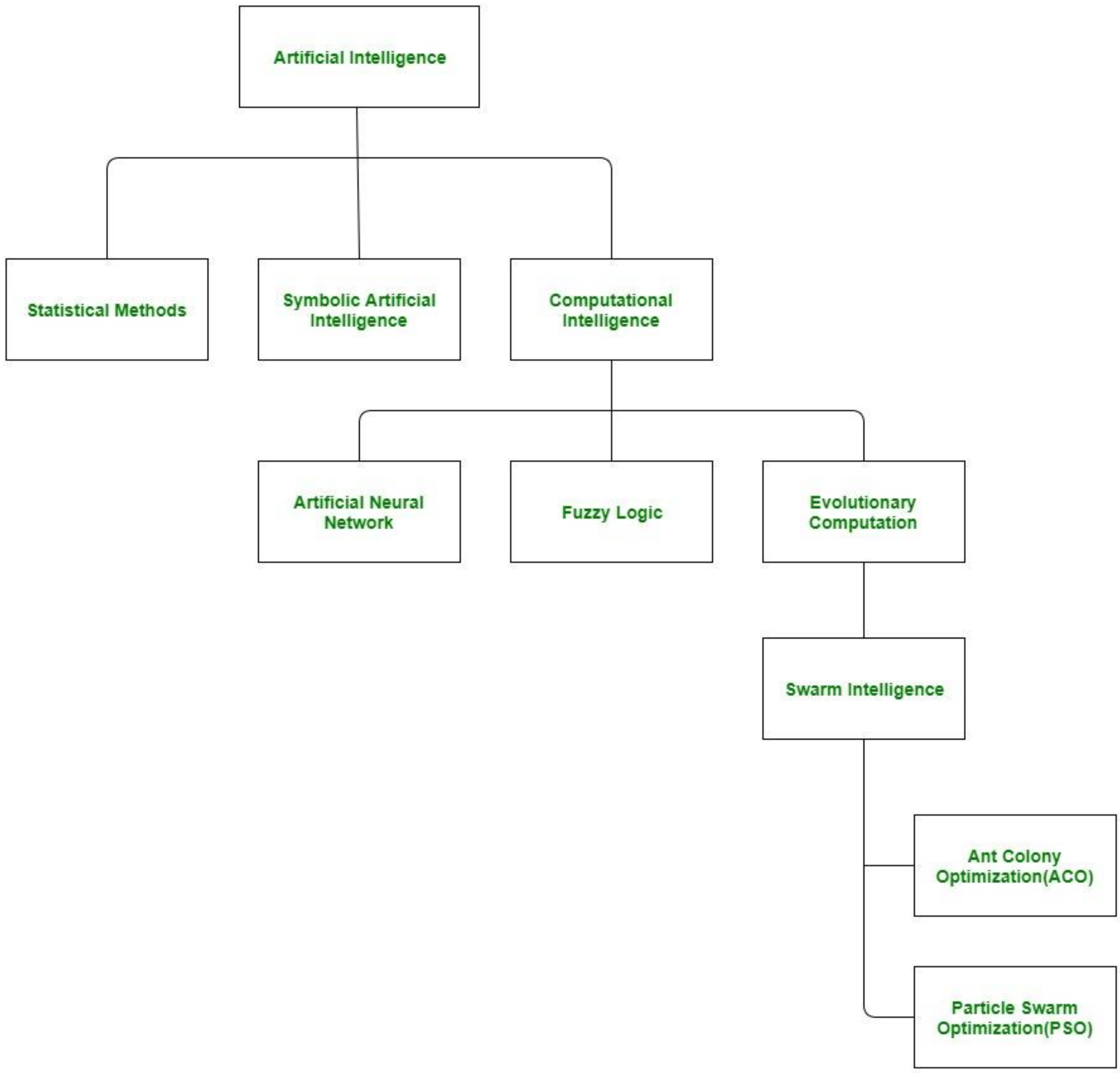
- Statistical Methods
- Symbolic Artificial Intelligence
- Computational Intelligence

Computational Intelligence can be implemented using either of the three methods:

- Artificial Neural Network
- Fuzzy Logic
- Evolutionary Computation

Note: Under Evolutionary Computation, are the Swarm Intelligence Techniques which include Particle Swarm Optimization.

As described earlier, Swarm Intelligence is a branch of Artificial Intelligence where we observe nature and try to learn how different biological phenomena can be imitated in a computer system to optimize the scheduling algorithms. In swarm intelligence, we focus on the collective behavior of simple organisms and their interaction with the environment.



There are two types of Optimization algorithms in Swarm Intelligence:

- The first one is Ant Colony Optimization(ACO). Here the algorithm is based on the collective behavior of ants in their colony.
- The second technique is Particle Swarm Optimization(PSO).

In PSO, the focus in on a group of birds. This group of birds is referred to as a 'swarm'. Let's try to understand the Particle Swarm Optimization from the following scenario.

Example: Suppose there is a swarm (a group of birds). Now, all the birds are hungry and are searching for food. These hungry birds can be correlated with the tasks in a computation system which are hungry for resources. Now, in the locality of these birds, there is only one food particle. This food particle can be correlated with a resource. As we know, tasks are many, resources are limited. So this has become a similar condition as in a certain computation environment. Now, the birds don't know where the food particle is hidden or located. In such a scenario, how the algorithm to find the food particle should be designed. If every bird will try to find the food on its own, it may cause havoc and may consume a large amount of time.

Thus on careful observation of this swarm, it was realized that though the birds don't know where the food particle is located, they do know their distance from it. Thus the best approach to finding that food particle is to follow the birds which are nearest to the food particle. This behavior of birds is simulated in the computation environment and the algorithm so designed is termed as Particle Swarm Optimization Algorithm.

Artificial bee colony system

Artificial Bee Colony (ABC) algorithm is a swarm-based meta-heuristic technique used for numerical problem optimization. It was inspired by honey bees' clever foraging behavior. The model is made up of three key components: employed and unemployed foraging bees, as well as food sources.

About Bee Colony

Food sources, employed bees, unemployed bees, foraging behavior, and dances may all be summarized in the brains of genuine honey bees.

About Artificial Bee Colony (ABC)

Honey bees' foraging behavior inspired the ABC algorithm. The honey bee swarm is an example of a natural swarm that searches for food in a coordinated and intelligent manner. The honey bee swarm has several characteristics, including the ability to convey information, memorize the surroundings, retain and distribute knowledge, and make decisions based on that information. The swarm adapts to changes in the environment by dynamically assigning jobs and progressing through social learning and teaching.

ABC algorithm is a population-based optimization method that evaluates fitness, therefore the population of candidate solutions is predicted to gravitate toward the search space's better fitness areas. Through natural motivation, population-based optimization algorithms find near-optimal solutions to challenging optimization problems.

Working of ABC

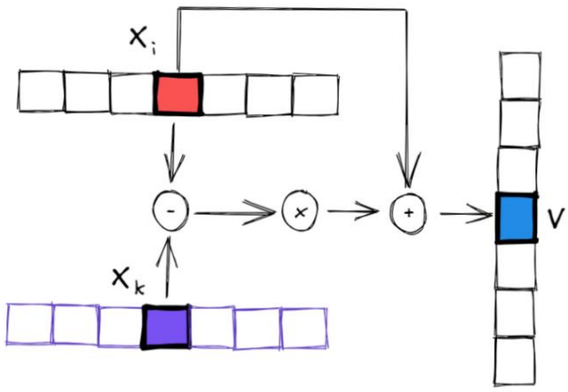
Swarm-based optimization algorithms use collaborative trial and error approaches to identify solutions. The ABC optimization algorithms are driven by the peer-to-peer learning behavior of social colonies. ABC consists of a population of potential solutions and finds the optimal solution with an iterative process.

The two essential factors that determine the development of an ABC population are variation and selection. The variation process explores diverse sections of the search space. The selecting procedure guarantees that past experiences are utilized.

The ABC algorithm is divided into four phases: the initialization phase, the employed bees phase, the scout and the onlooker bees phase.

In the initialization of the population, ABC generates a uniformly distributed population of solutions where each solution is a dimensional vector. The number of dimensions depends on the number of variables in the optimization problem for a particular food source in the population.

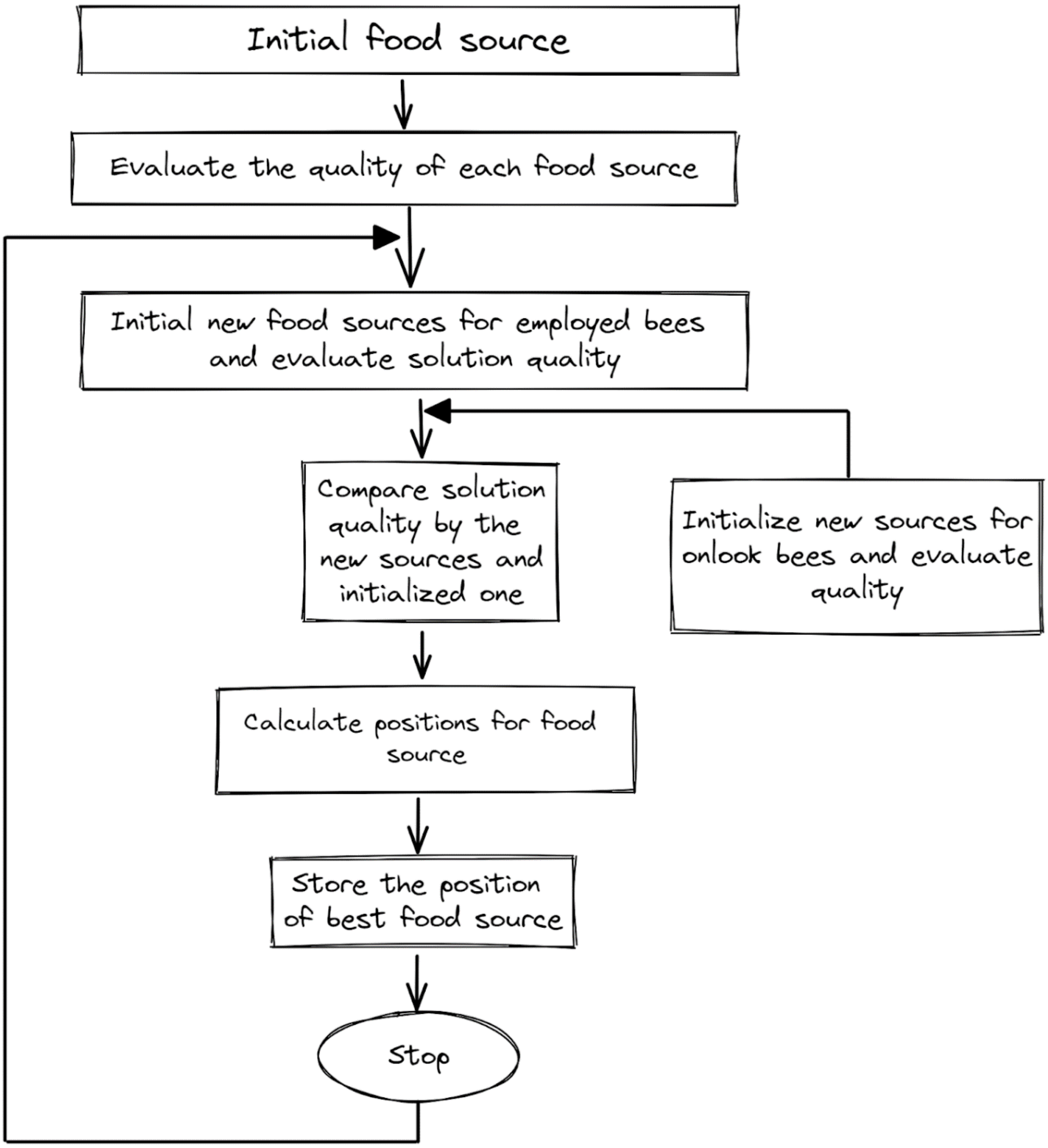
The employed bees modify the current solution based on the information from individual experiences and the fitness value of the new solution. If the fitness value of the new food source is higher than that of the old food source, the bee updates the position with the new one and discards the old one. The position is updated using the dimensional vectors defined earlier in the initial phase with the size of steps needed to get the updated positions. Step size is a random number between –1 to 1.



The accompanying diagram depicts the position updating procedure in the employed bee phase. A two-dimensional search space is used. The highlighted box depicts the randomly chosen direction, while Xi displays the current position of a bee. Xk is the chosen bee at random. The direction of a random bee is subtracted from the same direction of the specified group of bees in this phase. This difference is compounded by the step size, which is a random integer. Finally, the dimension of the new food position 'V' is calculated by adding this quantity to the dimensional vector of Xi. This vector is formed in the vicinity of Xi and has the same other dimensions as Xi.

With the spectator bees in the hive, the employed bees communicate the fitness information (nectar) of the updated solutions (food sources) as well as their location information. Onlooker bees evaluate the given data and choose a solution based on its fitness likelihood. As with the employed bee, the observer bee modifies its memory location and assesses the suitability of the prospective source. The bee memorizes the new location and forgets the old one if the fitness is higher than the previous one.

The position of a food source is deemed to be abandoned if it is not updated for a predefined amount of cycles. The abandoned food source's bee transforms into a scout bee, and the food source is replaced with a randomly selected food source inside the search space. The set number of cycles, known as the limit for abandonment in ABC, is a critical control parameter.



How is it utilized to optimize problems?

In order to customize the ABC algorithm for issue solving. Deb's constrained handling approach is utilized instead of the ABC algorithm's greedy selection procedure since Deb's method only has three heuristic criteria. Deb's technique employs a tournament selection operator, which compares two solutions at a time and always enforces the following requirements.

- Any viable solution is preferred over an infeasible solution.
- The one with a higher objective function value is preferred between the two feasible solutions.
- The one with a lower constraint violation is preferred between the two infeasible alternatives.

he ABC method does not regard the initial population to be viable since initialization with feasible solutions is a time-consuming procedure. In certain circumstances, it is impossible to construct a feasible solution randomly. Because Deb's principles were used instead of greedy selection, the structure of the algorithm already steers the solutions to a viable area in the running process. The algorithm's scout creation process provides a diversity mechanism that permits new and likely impossible individuals to enter the population.

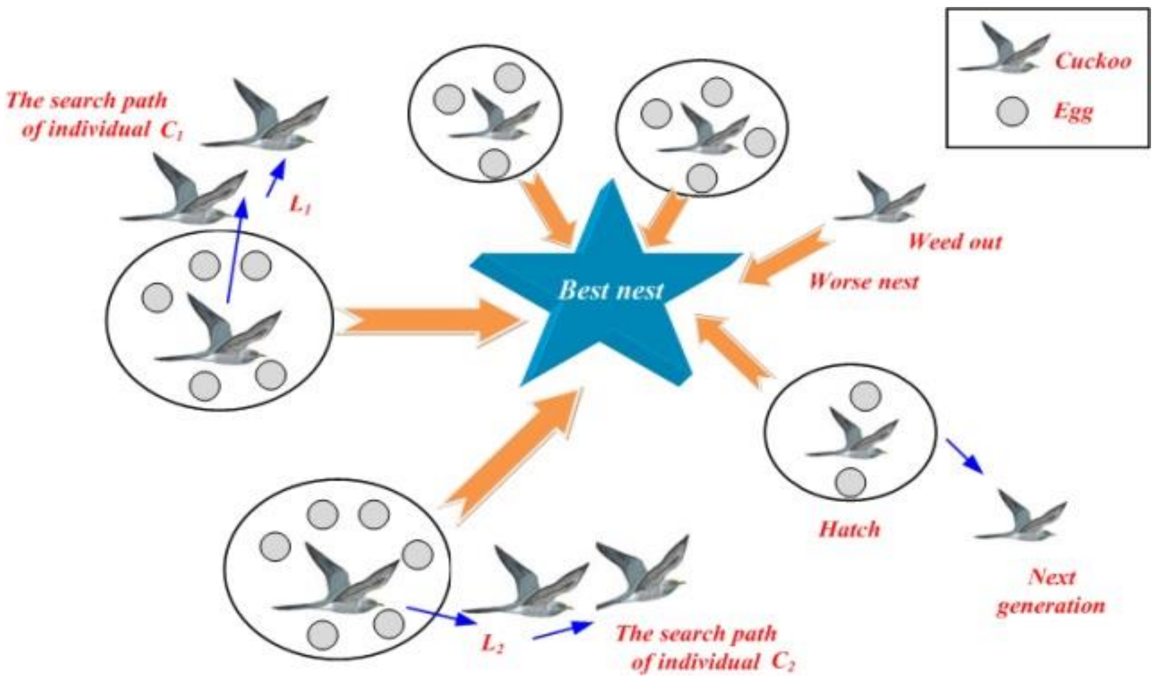
Cuckoo Search Algorithm

The cuckoo search algorithm has been used to optimize solutions in cloud computing, data mining, software testing, IoT, and pattern recognition. Because there is only one parameter, Pa, this algorithm is very simple to implement.

Yang and Deb created the cuckoo search algorithm in 2009. It was inspired by the cuckoo birds. Cuckoo birds lay their eggs in the nests of the other host birds. The first fundamental motivation for developing a new optimization algorithm is cuckoo egg laying and breeding. If the host bird recognizes the eggs as not being their own then it will either throw the eggs away from its nest or simply empty the nest and build a new one.

Each egg in a nest represents a solution. Cuckoo egg represents a new and good option. The answer obtained is a new option based on the existing one with some characteristics modified. In its most basic form, each nest has one cuckoo egg, and each nest with multiple eggs represents a set of options. Cuckoo search has idealized this breeding behavior. Cuckoo search algorithm can be applied to a wide range of optimization problems. This optimization algorithm improves efficiency, accuracy and convergence rate.

To begin, each cuckoo can only lay one egg at a time. Then deposit it in a randomly selected nest. Secondly, the best nests with high-quality eggs will be passed down to future generations. Thirdly, the number of available host nests is fixed:



Steps of the Cuckoo Search Algorithm

Now, let's discover the steps of the cuckoo search algorithm.

- Initialization: Cuckoo birds prefer to lay their eggs in the nests of other birds.
- Levy Flight: It is a random flight or walk. The steps are defined in terms of step lengths that have a certain probability distribution with random directions. This type of flight is observed in different animals and insects. The following movement is determined by the current position.
- Fitness Calculation: Calculation of fitness is achieved by using the fitness function to find the best solution. Nest is chosen randomly. The fitness of the cuckoo egg (new solution) is then compared to that of the host eggs (solutions) in the nest. If the value of the cuckoo egg's fitness function is less than or equal to the value of the randomly chosen nest's fitness function, the randomly chosen nest is replaced by the new solution.
- Termination: The fitness function compares the solutions in the current iteration and only the best solution is passed further. If the number of iterations is less than the maximum, the best nest is retained. All cuckoo birds are ready for their next actions after completing the initialization, levy flight, and fitness calculation processes. The cuckoo search algorithm will be terminated once the maximum number of iterations has been reached. These steps are applicable to any optimization problem. In such cases, each cuckoo egg and cuckoo nest play an important role.