



Decoderz

📅 August 26, 2019 📁 [AI techniques](#) 💬 No Comments

A Bumble Bees Mating Optimization (BBMO) Algorithm to solve Numerical Optimization Problems

1. Introduction

In computer science and operations research, the bee's algorithm is a population-based search algorithm which was developed by Pham, Ghanbarzadeh et al. in 2005. It mimics the food foraging behaviour of honey bee colonies. In its basic version the algorithm performs a kind of neighborhood search combined with global search, and can be used for both combinatorial optimization and continuous optimization [1]. The only condition for the application of the bee's algorithm is that some measure of distance between the solutions is defined. The effectiveness and specific abilities of the bee's algorithm have been proven in a number of studies. During the last decade nature inspired approaches, like Particle Swarm Optimization, Ant Colony Optimization, bees inspired algorithms have become increasingly popular. The bees inspired algorithms are divided, mainly, in two categories according to their behavior in the nature, the foraging behavior and the mating behavior. A colony of honey bees can extend itself over long distances (over 14 km) and in multiple directions simultaneously to harvest nectar or pollen from multiple food sources (flower patches) [2]. A small fraction of the colony constantly searches the environment looking for new flower patches. These scout bees move randomly in the area surrounding the hive, evaluating the profitability (net energy yield) of the food sources encountered. When they return to the hive, the scouts deposit the food harvested. Those individuals that found a highly profitable food source go to an area in the hive



the food source it discovered to collect more food. As long as they are evaluated as profitable, rich food sources will be advertised by the scouts when they return to the hive. Recruited foragers may waggle dance as well, increasing the recruitment for highly rewarding flower patches. Thanks to this autocatalytic process, the bee colony is able to quickly switch the focus of the foraging effort on the most profitable flower patches [3].

2. Life Cycle of BBMO

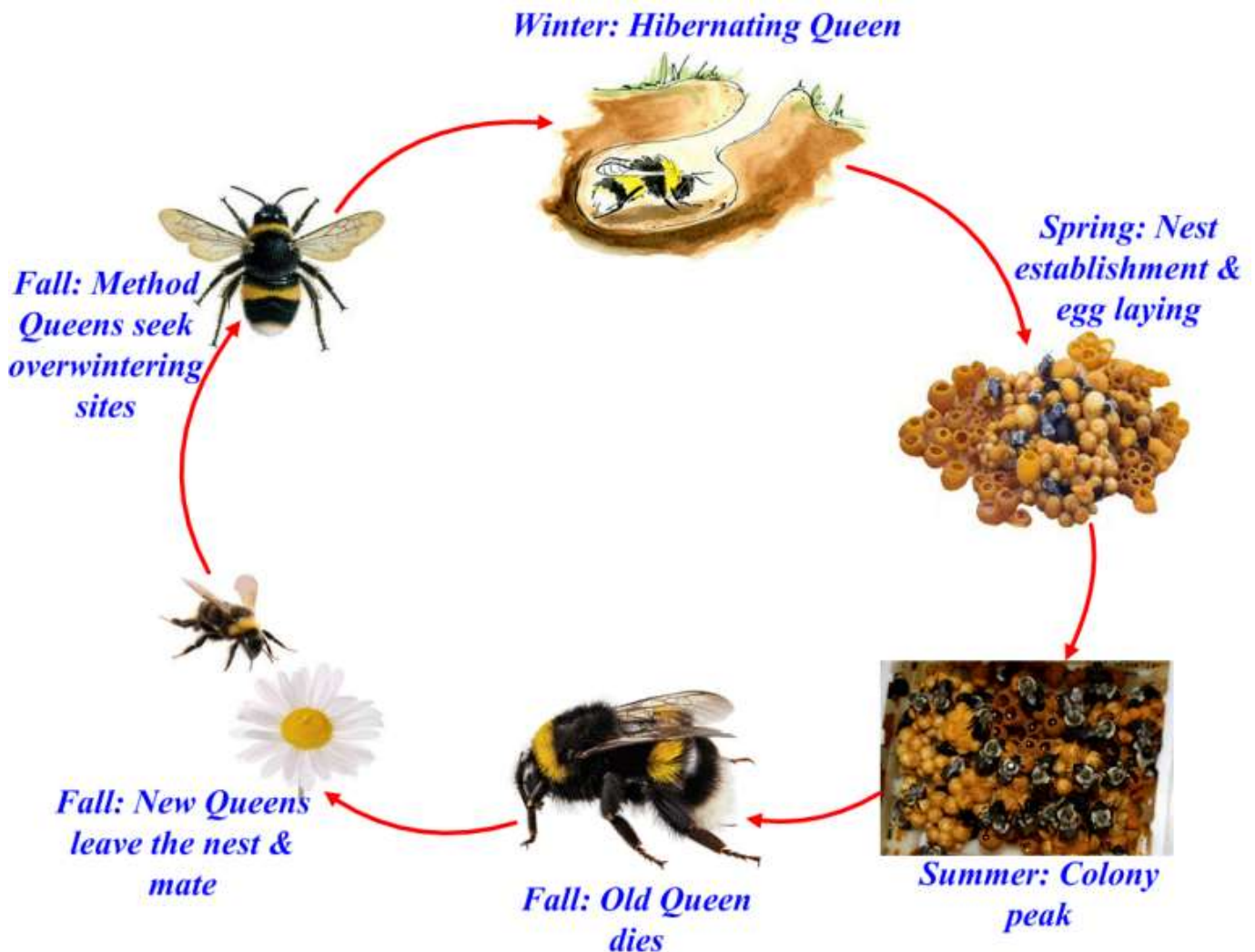


Fig1: Life Cycle of BBMO

Bumblebee colonies have a yearly cycle, except for some tropical bumblebees where the year-round availability of flowers allows colonies to survive for more than

These queens haven't eaten anything since the previous summer, so they are hungry. This is why it is vitally important that they find early flowers to feed [5]. Newly emerged queens eat both nectar and pollen, and it is the pollen that helps her ovaries develop. A bumblebee cannot fly unless her flight muscles are at 30°C, so she has to brave the cold weather to feed or else she will sink into torpor and never wake up. She continues feeding and sheltering at night near the food plants in nooks and crannies for a few weeks until her body signals her that it is time to find a nest site [6].

3. Bumble Bee Mating Optimization (BBMO)

Bumble bees are social insects that form colonies consisting of the queen, many workers (females) and the drones (males). Queens are the only members of the nest to survive from one season to the next, as they spend the winter months hibernating in a protected underground overwintering chamber. Upon emerging from hibernation, a queen collects pollen and nectar from flowers and searches for a suitable nest site and when she finds such a place, she prepares wax pots to store food and wax cells into which eggs are laid. The bumble bee queen can lay fertilized or unfertilized eggs [7]. The fertilized eggs have chromosomes from the queen and a male or males she mated with and develop into workers while the unfertilized eggs contain chromosomes from the queen alone and they develop into males. After the emergence of the first workers, the queen no longer forages as the workers take over the responsibilities of collecting food (foragers) and the queen remains in the nest laying eggs and tending to her young. Some workers, also remain in the nest and help raise the brood (household workers). Males do not contribute in collecting food or helping rear young as the sole purpose of the males are to mate with the queens. Bumble bee workers are able to lay haploid eggs when the queen's ability to suppress the workers' reproduction diminishes. These eggs are developed into viable male bumble bees. A few days after the males leave the nest, new queens will emerge. After new queens and males have gone, the colony begins to deteriorate. The founder queen stops laying eggs and grows weak from old age while the remaining workers continue to forage for food but only for themselves. Away from the colony, the new queens and males live off nectar and pollen and spend the night on flowers or in holes. The queens are eventually mated (often more than once), the sperm from the

queens of the same species will be attracted to the pheromones and follow the scent trail. The third mating behavior is where males wait at the entrance of a bumble bee nest for queens to leave [8].

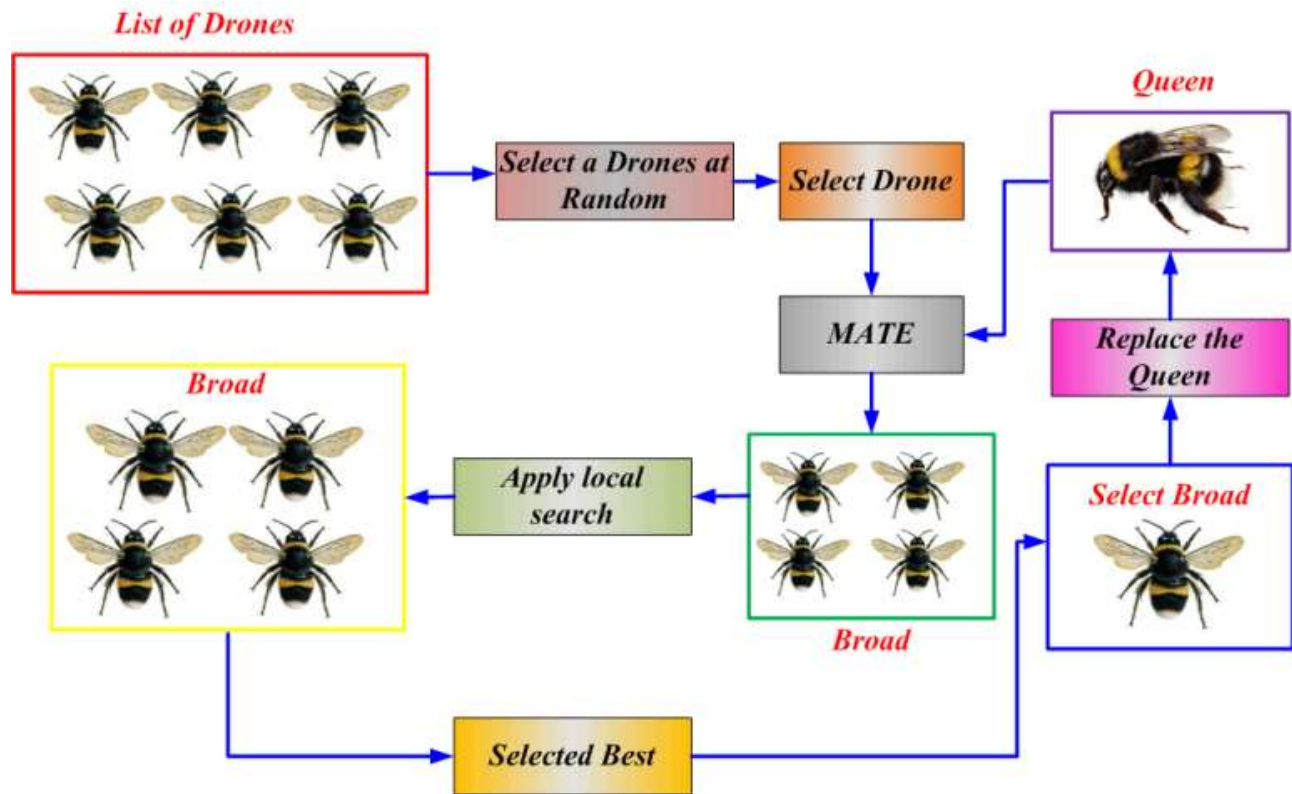


Fig2: BBMO Algorithm

3.1. Steps for Bumble Bee Mating Optimization

- Representation and Evaluation method
- Initial population
- Crossover operators
- Worker phase
- Multiple-descendant BBMO algorithm

3.1.1. Representation and Evaluation method

The solutions are encoded as permutation of n trips without any trip delimiters. These permutations could be interpreted as the order in which a vehicle must visit all

3.1.2. Initial population

The initial population is an array of n bees, each of which has two fields: the sequence of the permutation of the trip and the cost of the bee (quality), which is computed by the split function. The initial drones are initialized randomly. Each drone bee receives a randomly generated permutation of trips. However, a high-quality permutation can be obtained by merging all the generated routes [10].

3.1.3. Crossover operators

A combined crossover operator is used in the proposed HBMO algorithm. If necessary, the algorithm makes a selection from eight different crossover operators, which are adapted for the permutation problem to generate new broods. These crossovers are one-point crossovers type one and two, two-point crossovers type one and two, three-point crossovers type one and two, the cycle crossover (CX), and the partially matched crossover (PMX), which are adapted for permutation problems [11].

One-point crossover: A random cut point is selected for the two bees. The entire section before the cutting point is copied from the queen bee to the new brood. The missing trips are copied from the selected drone in their order of appearance [12]. This is the first type of one-point crossover. In the second type, the trips after the cutting point are copied from the queen to the brood. The other missing trips are copied from the drone to the brood in their order of appearance [13].

Two-point crossover: Two cutting points are made randomly in the two bees, which obtain three sub-sequences for each bee. This type of crossover copies the second sequence from the queen to the brood and the other two missing sequences are trips that are copied from the drone in their order of appearance. In the second type of this crossover, the trips between the two cutting points are copied from the drone to the brood and the remaining trips are taken from the queen.

Three-point crossover: This crossover produced three cutting points in the two selected bees in order to obtain four different sub-sequences of trips. The first and third sequences are copied from the queen to the new brood and the other missing parts are copied in their order of appearance from the drone [14]. This is the first type of three-point crossover. The second type of this crossover copies the trips from the

In order to enhance the quality of the solutions in the BBMO algorithm, a worker phase is introduced. In bees hive, workers' job consists mainly in brood care. Thus the worker phase is regarded as a specific heuristic that aims to improve the set of broods. Generally, the worker phase consists of a local search phase in the BBMO algorithm. However, the BBMO algorithm introduces a strict parallelism of the local search phase in the worker phase. By doing so, the BBMO algorithm simulates what really happens in real life. In fact, each worker bee takes care of specific brood by feeding him in order to make him fittest. If the new fittest brood is better than the queen, then here place her. Therefore, the BBMO algorithm combines the mating process and the foraging process of honeybees [15].

3.1.5. Multiple-descendant BBMO algorithm

An extension of the basic BBMO algorithm is also proposed in the present study, which integrates a different crossover scheme. The BBMO mating process aims to mate the queen bee with one of theselected drones, thus the multiple-descendant crossover scheme wasintegrated into the proposed BBMO algorithm. The multiple-descendant crossover scheme is based on the principle that a largesearch space can be explored as the number of descendants isincreased. The proposed BBMO algorithm simultaneously appliesdifferent crossover operators to obtain different new broods from thesame queen and drone [16]. This algorithm simultaneously applies the eightcrossover operators used in the simple version of the BBMO to obtaineight different broods. Next, only the best brood is selected to enter theworker bee phase.

3.2. Flow Chart of BBMO Algorithm

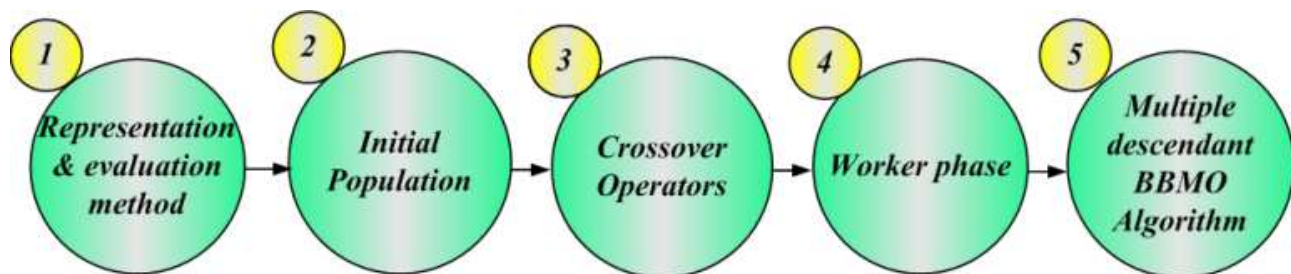


Fig3: Flow Chart of BBMO Algorithm

✓ 4. Numerical methods of BBMO Algorithm

$$L_1 = (u_{bound} - l_{bound}) \times (\omega_1 - \frac{\omega_1}{iter_{max}} \times t) + l_{bound}$$

$$L_2 = (u_{bound} - l_{bound}) \times (\omega_2 - \frac{\omega_2}{2 \times iter_{max}} \times t) + l_{bound}$$

Where,

$t \rightarrow$ Current iteration

$iter_{max} \rightarrow$ Maximum number of iteration

u_{bound} and $l_{bound} \rightarrow$ Upper and Lower bounds

ω_1 and $\omega_2 \rightarrow$ Parameters

l_1 and $l_2 \rightarrow$ Control the range of values

$$L_1 = (u_{bound} - l_{bound}) \times (\omega_1 - \frac{\omega_1}{iter_{max}} \times t) + l_{bound}$$

$$= (4.54 - 2.66) \times (0.12 - \frac{0.12}{84.4} \times 3.21) + 2.66$$

$$= 1.88 \times (0.12 - 0.0014 \times 3.21) + 2.66$$

$$= 1.88 \times (0.12 - 0.0045) + 2.66$$

$$= 1.88 \times 0.115 + 2.66$$

$$L_1 = 2.8762$$

$$L_2 = (u_{bound} - l_{bound}) \times (\omega_2 - \frac{\omega_2}{2 \times iter_{max}} \times t) + l_{bound}$$

$$= (4.54 - 2.66) \times (0.04 - \frac{0.04}{2 \times 84.4} \times 3.21) + 2.66$$

$$= 1.88 \times (0.04 - 2.369 \times 3.21) + 2.66$$

$$= 1.88 \times (-7.564) + 2.66$$

$$= -14.22 + 2.66$$

$$L_2 = -11.56$$

$$\text{Number of drones per colony} = \frac{\text{Number of drones}}{\text{Number of queens}}$$

$$= \frac{25}{5} = 5$$

$$\text{Number of drones per colony} = 5$$

5. Applications of BBMO Algorithm

- Function Optimization
- Training classifiers like MLP, LVQ, RBF and SNNs
- Electronic Designs[18]
- Mechanical Designs
- Digital Filter Optimization
- Data Clustering[19]
- Robot control

