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Research Paper

Modified drosophila optimization algorithm for managing re-sources in cloud environment

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Abstract

Optimizing a problem is common among the researchers in all the fields. The worst case of the optimization problem is that when it is not solved by putting lots of efforts and human capital is spoiled in dealing with the problem. So, to search for the optimal solution of a problem is becoming a tedious job for the scholars. Many algorithms have been applied to solve these long-standing complex problems. In this paper, Drosophila Food search optimization (DFO) Algorithm is applied, which explores its vision foraging behavior in the global optimization process. The objective behind the use of DFOA is to achieve fast computation, maximizing resource utilization and minimizing makespan. The survey of our work presents the state-of-the-art in recent research.

Keywords: *Nature-Inspired Algorithms; Drosophila Food Search Algorithm; Resource Availability; Cloud Computing*

1. Introduction

Nature Inspired Algorithms have proved their efficiency due to their attraction towards an immense performance in real-world optimization problems. Nature-inspired algorithms are a set of swarm intelligence and evolutionary algorithms that have been used to solve optimization problems in science and engineering. The inspiration for using nature's algorithm is the behavior and capability of insects, animals, birds and other living organisms that actually exist with their unique features. All the organisms inherit some common features like self-organization, decision-making, coordination instead of searching strategy [1]. Despite the high efficiency of nature-inspired algorithms, not all the algorithms are able to solve the problems efficiently.

1.1. Why using nature-inspired algorithms

We are underlying Advantages of Nature-inspired algorithms (NIA) in brief [2]:
Solution for real-world Problems: Other existing methods are not effective to deal with the problems that are bigger in size and other aspects. Nature-inspired
Algorithms have shown super performance in these kinds of optimization problems.
Parameter Control: basic parameter tuning and control is used to switch between the iterations for exploring and exploiting moves.
Self-Organization: Complex problems with large size, long time are easily managed by NIA self-organizing feature.
Choice of algorithm: NIA has a large set of algorithms to solve the optimization problem. The user can implement any natural algorithm suiting the criteria.
Hybridization with other techniques: NIA algorithms can be hybridized with the other traditional methods to get the powerful results.
Nature's Swarm Intelligence based algorithms exhibits common feature of decentralized and self-organized systems. Self-organized systems manage its components itself without the help of outsiders whereas decentralization allows the swarms to work separately to handle the problems. The algorithms: Particle Swarm Optimization (PSO), Ant Lion Optimizer (ALO), Ant Colony Optimization (ACO), Grey-wolf Optimizer (GWO) are the types of Swarm Intelligence algorithms [2] [4]. The phenomena behind NIA optimization algorithms is that NIA starts by initializing the randomly generated population called swarm that gives the search space for possible solutions and works iteratively until best optimal solution is found [5]. At each stage, swarms explore the search area, ending iteration with an optimal solution.
Nature-Inspired Optimization Algorithm provides a method of building a fully functional system. Optimization is a powerful process that lays down the multiple alternative solutions for the long-standing computational problems like pattern recognition, shift arrangement, designing and manufacturing systems, optimal route problems etc. [16]. The reasons for adopting these algorithms are: faster problem solving ability, search for optimality, robustness, hybridization, continuous optimization. All these features have brought the researchers to deeply study and make use of such methodologies in their research. Two main common features of nature algorithms are: Exploration and Exploitation [14].
Exploration: Exploration phase explores the search space on a global scale. It uses the information to generate new solutions better than the others. The initial location is given randomly.
Exploitation: It performs the local search to obtain an optimal solution around the current solution. Exploration avoids the solutions at local space rather concentrates on finding the candidate solutions globally. Exploiting the information on every local region boosts the process to find the best optimal solution.
In this paper, we will introduce a new optimization algorithm which is inspired by the life of fly, named as Drosophila Optimization Algorithm. The inspiration of using the algorithm is based on smell concentration, sensilla, vision, and olfactory organs. Drosophila also has another biological name called fruit fly and Vinegar fly. We will use both the names interchangeably.

We have organized our paper as follows: Introduction to basic FOA and survey in section 1 and 2. In section 3, we have provided mathematical model, and formulation of our proposed algorithm. Section 4 for Results and Discussions and last we have concluded in section 5.

1.2. Basic concept of drosophila optimization algorithm

The Drosophila optimization algorithm is a latest method to find the food by using global optimization and their foraging behavior. It was proposed by Pan [3] and gave the advanced versions in next two years. The fly is 3 mm in length, 2 mm in width and is considered as a research model due to the strong vision and smell concentration. Drosophila lives in water region and needs temperate regions to survive [5].

Fig. 1: Body Look of Drosophila Melanogaster [6].

Drosophila is superior in sensing and perception. Its food searching process has two phases: first, it smells the food source from current location, it moves towards that promising location. When it comes near to that location, then it finds the food with the help of its vision and reach to the location consisting of best food [5]. We are showing the food finding iterative process of fruit flies in fig 2.

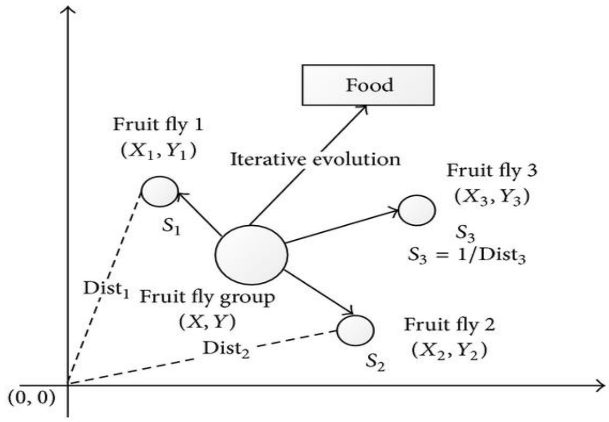

Fig. 2: Drosophila Food Searching Iterative Process [6]

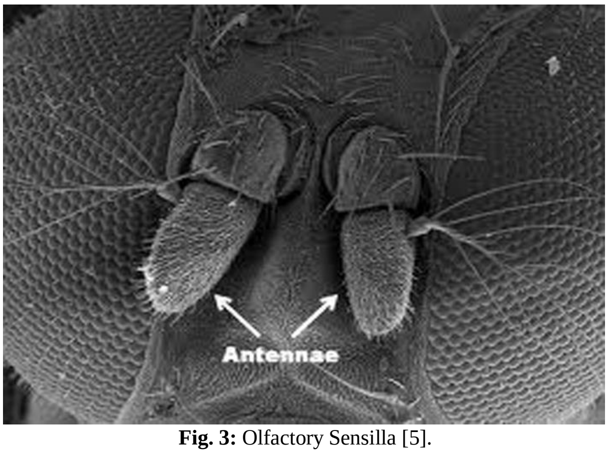

Fig. 3: Olfactory Sensilla [5].

Drosophila detects smell from olfactory sensory organs present on the head are: antenna and maxillary palp. The olfactory part of drosophila is covered by a number of sensory hairs (sensilla). Sensilla are of two types: internal and external sensilla. Internal sensilla checks for the food detected by the external sensilla. There is around 60 olfactory sensilla on the head and nearly 410 olfactory sensilla covers the antenna [5].

Two types of flies are there: Primer Flies and Follower Flies [2].

Primer Flies: A primer fly goes in search of a favorable food source and settle on the preferable food source at random.

Follower Flies: Follower flies doesn't search for the food, but are attracted towards the primer

Flies.

Basically two types of dance is performed by fruit flies: Tremble Dance and Waggle Dance.

Tremble Dance: Tremble Dance of the fly gives the signal of the availability of food.

Waggle Dance: When flies perform the waggle dance, it means that no food is available at that location and start finding the food in the new location.

1.3. Basic drosophila algorithm

The Basic Drosophila optimization algorithm is based on the following procedure given in the following steps:

Initialization Phase: Randomly initializes the swarm location to start the search.

X_0 = InitX_axis

Y_0 = InitY_axis (1)

Assignment Phase: Give random direction and distance for searching food-using osphresis.

$X_i = X_0$ +randValue $Yi = Y_0$ +randValue (2)

Evaluation Phase: Estimate the distance of the food source from the origin.

$\text{Dist}_i = \sqrt{X_i^2 + Y_i^2}$ (3)

On the basis of estimated distance, smell concentration judgment value S will be calculated.

$S_i = 1 / \text{Dist}_i$ (4)

Substitution Phase: Now find the smell concentration of the individual location of drosophila which takes the smell concentration judgment value S as an input.

Smell_i = Fitness Function (S_i) (5)

Identification Phase: Now, find the best smell concentration from equation 5.

[BestSmell_BestIndex] = max (Smell) (6)

Selection Phase: Now, Fruit flies will use their vision to reach to the best food source.

X_0 = X (BestIndex) (7)

Y_0 = Y (BestIndex)

2. Survey of variants of drosophila algorithm

The Standard drosophila algorithm was proposed by Pan in 2011 [3] which gave global search space to find the optimal solution. The method of finding the maxima and minima for the optimization process is unique. Exploration and Exploitation features make the algorithm efficient. However, somewhere we found that basic algorithm needs improvement. Some authors in many research papers have provided a modified fruit fly optimization algorithm to enhance the performance. Fruit Fly optimization algorithm has

gained a huge success in the area of financial distress [7], power load forecasting [8], service satisfaction in web auction logistics [10], Multidimensional knapsack problem [9], function testing [13], joint-replenishment problem [11], load balancing and Tuning PID Controller [12].
As studied from [5] [17], we have found the variants of Fruit fly algorithm:

- Basic Fruit Fly Algorithm: W.T. Pan [3] has presented the original algorithm. The drawback of this algorithm was that it could not solve multi-model optimization problems effectively.
- LGMS- based Fruit Fly Optimization Algorithm (LGMS-FOA): Shan et al. [14] have extended their work to include a linear generation mechanism of a candidate solution to enhance the performance of basic FOA. However, it was more effective than the previous but also has the problem of smell concentration judgment value which was non-negative.
- Improved Fruit Fly Optimization: Dai et al. [18] have presented their work with an improved judgment value and also proved the challenge with the better performance.
- Modified Fruit Fly Optimization algorithm (MFOA): A new modified FOA was proposed by Pan in 2013 [13] which added the third escape parameter that enabled the algorithm to find the solution globally rather than locally providing three dimensional search space.
- Multi-Swarm Fruit Fly Optimization Algorithm (MSFOA): The idea behind the proposed algorithm [20] was to bring several sub-swarms to work on the improvement of diversity of the solution in the explored radius. Shrinking of explored radius is another contribution to the work. Shrinking of the radius using osphresis depends on the number of iterations i.e. radius decreased with increased number of iterations and increased with the decreased number of iterations.
- High-Dimensional Fruit Fly Optimization Algorithm: Pan et al. [19] have introduced their work with the new control parameter and generated a new solution. The technique used 18 benchmark functions.
- Binary Fruit Fly Optimization Algorithm (BFOA): A binary string concept was introduced by Wang et al. [9], added a new group generating probability factor to generate population. The algorithm works in three phases: Evolutionary phase, vision-based search and smell-based search. The algorithm promised the feasibility of solution to enhance the performance.
- Grouped Fruit Fly Optimization Algorithm (GFOA): Zhang et al. [15] have provided the basic structure of the technique to optimize the number of Sublots, their sizes and sequence of the product. A cooperation based search was designed to optimize the result and improve efficiency.
  From the above study of Fruit fly variants, we have analyzed that different authors proposed their solution to find optimal solution according to their problem. A very little work is done to handle the problem of availability of service using a fruit fly algorithm. I have also found that the fruit fly optimization algorithm will be useful to get the best optimal results for utilization of resource, reducing makespan and increase availability. In our proposed work, I have used smell and vision-based method to optimize our problem. The smell concentration of fruit flies is superior to the other flies, so these flies capture the desired food quickly and gives the optimum value in less iteration.

3. Proposed algorithm

The proposed algorithm is inspired by the life of a bird's family, which comes under the category of nature-inspired algorithms. The researchers divided the nature-inspired algorithms into two broad categories: Evolutionary Algorithm and swarm intelligence Algorithm. Nature provides different ways to optimize the problem. Here, we are providing an algorithm from the family of nature-inspired Algorithm. The algorithm is modified as per the concept of the problem and uses the basic algorithm and provides an extended work with regard to the problem optimization.
Steps:
Initialization phase
Step 1: Create the initial population of ants (number of VM is created on a PM).
Step 2: Calculate the fitness function of each ant (VM) in the swarm (Cluster).
Step 3: Generate random location to search food. (Search for resource to execute task).
Osphresis Phase
Step 4: Primer flies uses osphresis organ which smells the food source (possible number of available resources) with the help of internal and external sensilla.
Step 5: After finding food (suitable resources), Primer flies get back to the food store (VM Monitor) which collects information regarding food.
Step 6: The flies start to perform a tremble dance (resource is found) in order to motivate the follower flies to move to the preferable food source (flies find more resources around the best one since the possibility around that resource is a maximum Optimal resource).
Vision Phase
Step 7: The flies also use their vision to find the neighbors around the best food source.
Step 8: The duration and special direction of the dance is the signal of a location of Food.
Step 9: The flies also perform the waggle dance (resource not found) if the food does not found.
Step 10: Stop the process after finding the best food.

3.1. Objectives

1) Reducing Makespan

Makespan is defined as the overall task completion time. Makespan measures the performance of the algorithm and it should be minimum for an efficient algorithm.
Ft1 = minimize (F1)

2) Efficient VM Utilization:

Resource utilization is defined as the measurement of time in which the resource was busy to execute the task. Resource utilization should be maximum in order to achieve high performance and it is given by:
Ft2 = maximize (F2)

3) Availability of resource

Ft3 = maximize (F3)

3.2. Mathematical modelling and flowchart

To represent our mathematical model, we consider an undirected graph G with a set of nodes M and arcs L, where M = {0, 1, 2… m} and a set of arcs L = {a, b} joining each other and also a ≠ b & both {a, b Ɛ M}.

Table 1: Notations and Definitions

Notations	Definitions
M	Set of Virtual Machines
K	Number of tasks to be executed
P_{ij}	Processing time of task K_i virtual machine M_j
C_j	Capacity of the jth virtual machine
P	Mean processing time of all VM
A_M	Availability of virtual machine M
R	Resource utilization
num_E_j	Total number of processing elements in M_i
$mips\_E_j$	Million instructions / second
bt_M_j	Bandwidth of the virtual machine M_j
Q_w	Maximum work done by the machine
G_w	Expected work done

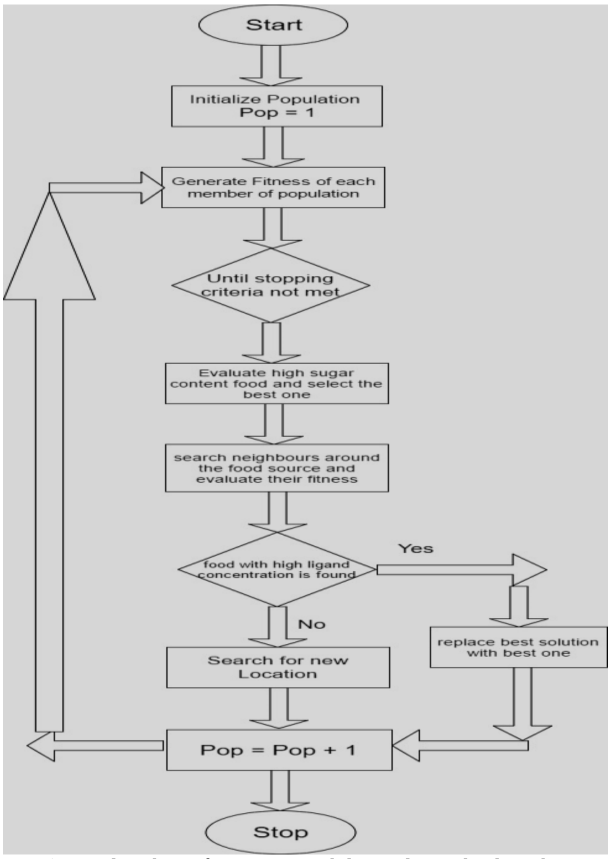

Fig. 4: Flowchart of Basic Drosophila Food Search Algorithm.

3.3. Formulation of proposed algorithm

The Objective of the algorithm is to optimize the availability of resource and maximize the throughput

1) Initialize the population $M = \{M_1, M_2, M_3 \ldots\ldots\ldots\ldots\ldots M_m\}$ where j = {1,2,3,…….. m} , j Ɛ M

$K = \{K_1, K_2, K_3 \ldots\ldots\ldots\ldots\ldots K_i\}$ where i = {1, 2, 3… n}

Now, Calculate

F_1= start time of K_i + Execution time of K_i (8)

Where Execution time = length of the task / C_j

Capacity C_j = num_E_{j*} mips_E_j + bt_M_j (9)

Here, Fitness function will give the optimal solution.

2) Generate random locations a, b, c, d where a ≠ b & c ≠ d also {(a, b, c, d) Ɛ m.
3) Find the availability of the resource

AM = Qw – GW (10)

Calculate $F_2 = \frac{\text{no.of actual hours spent}}{\text{no.of available hours}} * 100$

4) Generate new population parallel with new random locations:

$M1 = \{new_1, new_2, new_3 \ldots new_q\}$ and {new_a, new_b, new_c, new_d}5. If the fitness function gives the best solution, then stop otherwise go to step 4.

The performance of the proposed approach is evaluated on the basis of maximum and minimum values with the functions:

$Y = -5 + X^2$

$Y = 2 - X^2$

Optimization Process

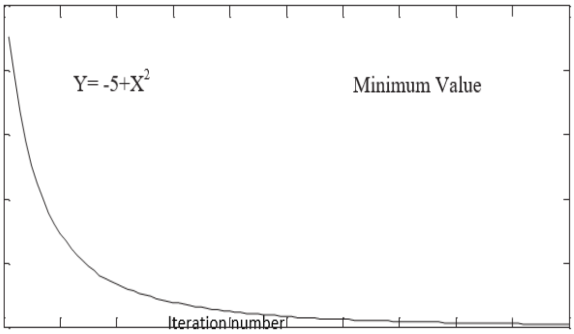

Fig. 5: (A): Solution Curve [3].

Optimization Process

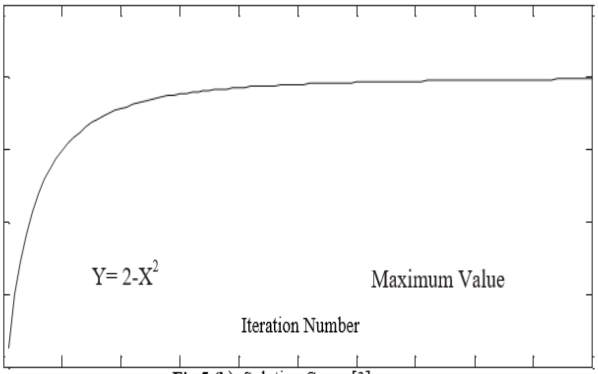

Fig. 5: (B): Solution Curve [3].

4. Experimental study and result

In this section, we are providing a list of parameters which we have used in the result analysis. To show how much better the proposed algorithm has performed, we have prepared comparison tables and charts in order to compare the resource utilization, processing time, and makespan of the proposed algorithm from the other algorithms as shown in tables 2 to 4 and in figure 6 to 7s. We have also compared proposed algorithm from PSO, CSO and ACO in terms of resource utilization, makespan and processing time. From the comparisons made among them, we found that proposed algorithm outperform than the other three. The comparisons from Table 2 to table 4 are shown along with their data charts.

Table 2: List of Parameters for Analysis of Result

Parameters	Values
Capacity_of_VM	50
Mips_of_VM	500-2000
Bandwidth_of_VM	100-2000
Number_of_Elements	1-5
Task_length	50-1000
Task_to_be_executed	40-1050
Datacenters	5
No_of_VM	2-5

Table 3: Comparison of VM Utilization of PSO, CSO, ACO and Proposed FOA

Virtual Machine	PSO	CSO	ACO	Proposed FOA
VM1	1000	248	343	290
VM2	88	251	292	270
VM3	50	220	340	270
VM4	20	230	200	290
VM5	5	248	70	290

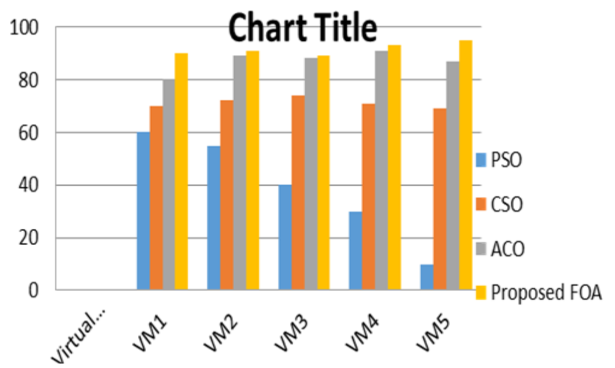

Fig. 6: Comparison of VM Utilization of PSO, CSO, ACO and Proposed FOA

Table 4: Comparison of Average Processing Time

Algorithm	Processing time
PSO	325.25ms
CSO	349.45ms
ACO	322.78ms
Proposed FOA	320.34ms

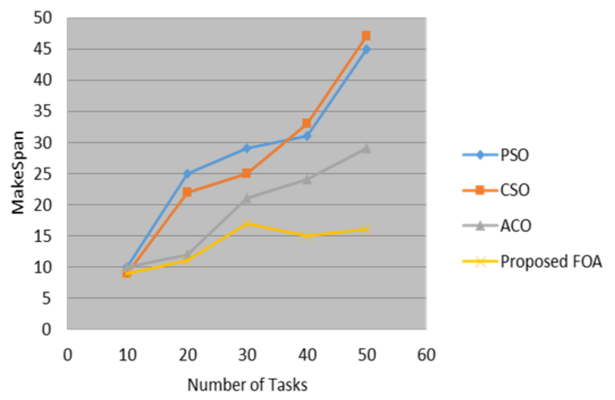

Fig. 7: Comparison of Make span of PSO, CSO, ACO and Proposed FOA

5. Conclusion

Many algorithms for solving a complex problem are provided. Lots of experiments were carried out to have the best optimal results. We have analyzed the performance of FOA discussed in previous section.

To evaluate the effectiveness of the proposed FoA, we have compared from PSO, ACO, and CSO. The algorithms checked under parameters such as utilization, processing time and makespan. It has been clear from results that the proposed scheme is performing well undoubtedly. In future work, we will extend our work on improvement of exploitation ability to provide more optimal results in the broadest global search space. Now we are ending the article by leaving the positive comments of Drosophila Optimization Algorithm. We are planning to make hybrid algorithm using the proposed one to cover up our next objective which will be more effective than the proposed FOA.

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