Amalgamation Of Nature Inspired Honey Bee Mating Optimization Algorithm With Metaheuristic Greedy Random Adative Procedure To Resolve Scheduling Problem In The Real World.

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Abstract

As humans come across so many problems and try to solve these problems either using our past experiences or by getting advises from different experts. People tend to get their solutions by working upon different or new algorithms as well. Nature too has so many problems which it tends to solve on its own. This is the time to get inspired from nature and mimic the nature in order to solve our problems as nature has always been able to resolve all its problems successfully on its own. It is to understand the fact that how nature responds to its environment and how we as humans too need to do the same to achieve our goals as nature is for sure being the most successful in all its work naturally and dedicatedly on its own. Nature has always amazed us with its extraordinary outputs which people could not even think at some point of time and while researching get to know that how nature is dealing with different sort of conditions people are not even aware of since years. One of the nature inspired algorithm known as Honey bee mating optimization algorithm is taken into consideration in this paper. The mentioned nature inspired algorithm is merged with a metaheuristic greedy random adaptive search problem to solve the problem on scheduling the tasks in real world. This has been realized using some more algorithms namely, Tabu Search and Simulated Annealing as both of these are also nature inspired algorithms. All these algorithms have been explained in the initial sections of the paper. The merge of algorithms to achieve result is explained in later sections of the paper. The quality and the efficiency with respect to computational response are also explained in this paper with an example using sample data of the different types of tasks. The results achieved are quiet promising as compared to the other approaches used for similar kind of problems.

Key words : Nature Inspired Algorithm, Honey bee mating optimization algorithm, Greedy Random Adaptive Search Algorithm, Simulated Annealing, Tabu Search, Cross over, Queen, Drones, etc.

1. Introduction

Nature Inspired algorithms have become popular during last few years. In order to solve many problems people have started looking, understanding and analyzing the nature. This is where we come across how nature is solving its problems on its own. Many algorithms have been derived after being inspired from one of the natures' techniques, behavior, response to certain stimuli, etc. An approach to understand the nature of honey bee mating optimization has been worked up on in this paper. In the animal world, honey bees perform one of the most complex processes for mating, communicating, selecting its partner, decision making, recognition, etc. An algorithm which mimics the mating process of honey bees is called Honey bee mating optimization algorithm.

One of the metaheuristic algorithms known as Greedy randomized adaptive search procedure is being merged with nature inspired mating optimization algorithm of honey bees to schedule tasks in a better or real world in this paper. The realization of this problem of scheduling tasks in real world is achieved by using two more algorithms namely, Tabu Search and Simulated Annealing along with the hybrid of nature inspired mating optimization algorithm of honey bees and metaheuristic Greedy randomized adaptive search procedure.

Scheduling the real time tasks include parameters such as the time frame required to complete a task or end date by which the task is supposed to be completed, the importance of the task on the basis of which the tasks are priororized and completed as per the priority. The aim of the scheduler is to get all the tasks completed efficiently before the end date.

In the initial sections of the paper, all these algorithms are discussed in detail. The approach of amalgamating the nature inspired algorithms with metaheuristic algorithm is explained in the middle sections. The result of the same has been analyzed in the last section of the paper along with the conclusion and future work details.

1.1 Honey Bees Mating in Nature

Honey bees perform one of the most complex processes in order to communicate, respond, mate, search, decision making , etc. when we go deep in the animal world. A hive of honey bee includes several types of bees which are basically divided in three categories. Each category has its own reason for its existence in the whole process.

Honey bees mating process includes three kinds of bees as mentioned below:

Queen bee, Worker bees and Drones.

Each type of these bees has its significant role in the mating process of honey bees. Queen bee lay eggs and is responsible for the generation or birth of bees called broods. Worker bees are infertile and they take care of the broods and selects the perfect brood to be replaced with the Queen. They are also responsible for taking care of the hives, maintaining the temperature, etc. Drones are the father of the broods.

Queen dances in the air and the drones chase the queen to mate with her. Queen selects the drone randomly or by probabilistic methods and allows the mating with the selected drone only as in Figure 1. Drones die after mating whereas the queen lives for around 5-6 years. Queen mates with around 15-20 drones in a mating flight as in Figure 2. The mating occcurs probabilistically in case the fitness and speed of the queen is compatible with the drone. The sperms of each dead drone is stored in the spermatheca of the queen after mating. Queen's energy is determined at the beginning of flight and it keeps on reducing after each flight. And, queen returns to its hive in case its spermatheca is completely filled or its energy has reduced to zero.

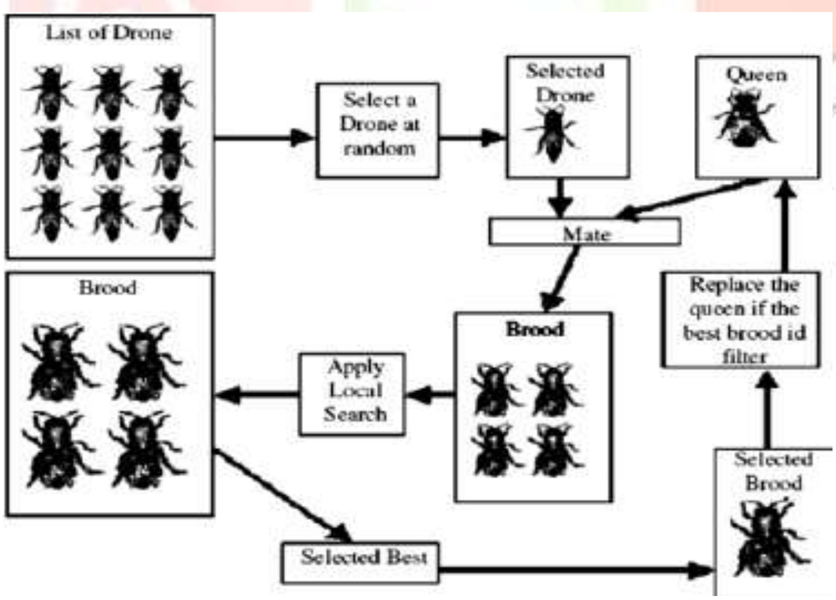

Figure 1 Mating Process of Honey Bees

Source: Reference [10]

Figure 2 Drones mating with Queen bee

Source: Reference [11]

1.2 Honey Bees Mating Optimization Algorithm

The Queen bee selects the drones randomly or on probabilistic basis. The mating occurs probabilistically in case the fitness and speed of the queen is compatible with the drone .The fertilized eggs become broods later on and are analyzed and taken care by workers bees.

Worker bees select the brood suitable for replacing the queen. Better the brood selected for replacing the queen the more fit the worker bees are. The betterment of brood is computed as per the number of fertilized eggs are being generated by the brood.

1.3 Greedy Randomized Adaptive Search Procedure

This is also called as GRASP and it is a metaheuristic algorithm which is commonly used for finding out optimal object from a set of finite objects. This type of search is combinatorial algorithm. Greedy randomized adaptive search procedure is done in two steps. First step is that the solutions are found via several iterations solutions and adaptive randomized greedy function. Second step is that the solutions found in the iterations go under random local search procedure holing to find some improvements.

1.3 Simulated Annealing

It is a probabilistic method which is used for solving global optimization problems which are unconstrained and bound- constraint. This technique is used on a large search space and usually used on discrete data. The physical process where a material is heated and then the temperature

is lowered down in order to decrease the defects which in turn minimizes the energy, is modeled by this method.

1.4 Tabu Search

This method is used for mathematical optimization for local search. Memory structures are used in the implementation of Tabu search which provide the solutions which have already been visited or the set of rules provided by users.

2. Problem: Scheduling Tasks in a Real Time System.

The scheduler's aim is to schedule the tasks on a processor in order to get the tasks completed on time and before its deadline arrives. The attributes to be considered for solving this problem include the Priority of the task, the taken to complete the task and the deadline of the task.

The number of tasks be n.

The process includes aggregation of two major functions.

Func1 : Minimization of the summation of the priorities of diffrents tasks which could not be performed or completed on time.

Func2 : Minimization of the delay in the whole Process.

Func1 (t+1)= { Func1(t) + Priority(n) if DelayProcess > Deadline(n)

Func1(t) otherwise } (1)

Func2 (t+2)= { Func2 (t) + DelayPricess- Deadline (n) if DelayProcess > Deadline(n)

Func2(t) otherwise } (2)

The merged function :

Func(t) = Func1 (t) + Func2 (t) (3)

This derives

$$Func(t+1) = \begin{cases} Func(t) + Priority(n) + DelayProcess - Deadline(n) & \text{if } DelayProcess > Deadline(n) \\ Func(t+1) & \text{otherwise} \end{cases} \quad (4)$$

3. Proposed Solution

To solve this scheduling tasks problem, it has been tried merge the nature inspired mating optimization algorithm of honey bees with the Greedy random adaptive search process. Apart from these two major algorithms, two more algorithms will be made use of namely, Search Annealing and Tabu search Algorithm.

The inspired mating optimization algorithm of honey bees imitates the natural mating process of honey bees. The Queen bee which is the best fit bee and having longest life among all other bees or drones in the hive, dances in the air and the Drones (the male bees) follow the Queen bee in order to mate with her and leaving their sperm in the spematheca of the Queen bee. The energy of the Queen keeps on decreasing after each flight. The Queen bee comes back to its hive in case either the spermatheca is full or energy level is just about to be zero or zero.

The Drones mate with the Queen in a probabilistic way as mentioned below :

Probability (Drone) = e[-delta(f)/speed(t)] (5)

Delta (f) is the absolute variance between the fitnesses of both Queen and Drone.

Speed (t) is the speed at time of the Queen.

Queen's speed and Energy keeps on evolving as follows :

Speed (t+1) = x * Speed (t) (6)

Energy (t+1) = x * Energy (t) (7)

X (0,1) is the amount of energy and speed getting reduced after each flight.

The worker bees work to identify the best brood among the generated broods (by Honey bee mating optimization algorithm) in order to replace the same with the Queen. This analysis and selection are done via Greedy Random Adaptive search algorithm.

Workers also go through selection procedure in order to be used for selecting the best fit brood. The search of the perfect workers is done via Simulated Annealing and Tabu search algorithm.

4. Merged Algorithm

```
Bees are selected to generate the initial population using Greedy Random Adaptive
Search procedure
Fitness of each plan is evaluated
Queen is selected as the best plan among others.
Size of Spermatheca defined : Sp
Energy(t) and Speed(t) defined
Factor of reduction of energy is defined , X
Maximum number flights for mating is defined , Mate_Max
For i=0 to Mate_Max
    do while  Energy (t)>0 and Sp is not Full
        Drone is selected
         if Drone satisfies probabilistic condition
             Drop its Sperm into th Spermatheca
         End If
    Speed ( t+1) = x * Speed (t)
    Energy (t+1) = x * Energy (t)
    End While loop
    For j= 1 to Sp
    Sperm is selected from spermatheca
    Brood is generated by crossing over the sperm with Queen's genotype
    Fitness of Brood is improved by Tabu/ Simulated Annealing by Worker bees.
     Evaluate date the fitness of Brood and replace it with the Queen if it is fitter than the
Queen.
     Else keep the brood in Drones Population
    End For
End For
Return Best Solution i,e. Queen
```

Table 1 Merging of Greedy Randomized Adaptive Procedure, Tabu Search/Simulated Annealing with Nature Inspired Honey Bee Mating Optimization Algorithm.

In the next section, it explains the process of generating the initial population or the tasks which will be selected using Greedy random Adaptive procedure of search and with its hybridization with Random Honey Bee mating optimization algorithm.

4.1 Greedy Random Adaptive Procedure of Search to generate the initial population

Greedy randomized adaptive search procedure is done in two steps. First step is that the solutions are found via several iterations solutions and adaptive randomized greedy function. Second step is that the solutions found in the iterations go under random local search procedure holing to find some improvements. The Algorithm is mentioned below.

```
Begin
    RCL: List of tasks Ti (ni, ci, di, pi)
    Select one random element from RLC to build solution on a random basis  or Hybridizati
    RCL ← GenerateTasks (s) // All to be scheduled tasks Ti
    build Solution ()
    { s ← Ø
     While  s ! completed
     { x← Choose Randomly (RCL) //Exclude tasks already in s
      s ← s U {x};   }
       Return s       } ;
       s*← build Solution ();
      Repeat
           s′ ← Build Solution ();
          Ameliorate (s′)//  local search
       If f(s′) < f(s*) Then begin
                s* ← s′;
                Add  s′ in the population;
                End;
      Endif
     Until the size of the population
End.
```

Table 2 Greedy Randomized Adaptive Search Procedure

Source: Reference [9]

In the next section, it will explain the two methods of brood solutions as the improvement strategies. The two methods are Tabu search and Simulated Annealing.

4.1 Improvement methods for brood solution

Simulated Annealing methods deals with the heating of metals. This heating or annealing process leads to a number of moves. Each move has a probability of making a change in the configuration of metal leading to its worse condition. It is a genetic algorithm which tries to avoid falling in local minimum or local maximum.

Tabu search is a method used for mathematical optimization for local search. Memory structures are used in the implementation of Tabu search which provide the solutions which have already been visited or the set of rules provided by users.

Tabu Search :

```
Begin
  Initial solution s (Broods to be improved);
    Insert s in the tabu List ;
     S_max ← s  //S_max : the best solution
       While (Don't check the criteria to stop) do
         Generate the neighborhood of the current solution by mutation of the
two operations.
         Select s1 in this neighborhood if  s1 is not present in the tabu list.
           If F (s1) < F (S_max) then begin
             S_max ← s1      //cost Function to be minimized
             Update the tabu list End;
           Endif;
       End while;
End
```

Table 3 Tabu Search

Source: Reference [12]

Simulated Annealing :

```
Begin
    Initial solution s (broods to be improved);
    Insert  T ← f(s); // fitness factor
    //Perform  mutations
    s1← Mutation (s);
    s1← offset (s1);
     If (f(s1) < f(s)) then
       return s1
     Else
       Generate a real number randomly r in [0, 1]
       If  r <  e^  [f(x)-f(x1)]/T    then
              return s'
       Else return s;
      Endif;
    Endif ;
End
```

Table 4 Simulated Annealing

Source : Reference [13]

5. Experimental Results and Discussions

This section deals with the implementation of the approach it has been worked upon so far in this paper.

Parameters and values of the defined approach :

Population size - 50
Number of Flights of mating - 100
Size of Spermatheca - 6
Speed - 0.90
Energy - 0.80
Factor of energy and Speed reduction- 0.20

Table 5- Honey Bee Randomized Mating Optimization

Initial Temperature - Brood Fitness
Terminal Temperature - 0
Number of iterations -Either Amelioration or Temp= 0

Table 6- Simulated Annealing

Size of list- 5
Iterations- 5
Neighborhood Type - With Mutation

Table 7- Tabu Search

Population Size - 50
Amelioration Algorithm -Local seach

Table 8- Greedy Randomized Adaptive Search Procedure

In order to study the effectiveness of this approach, three conditions have been considered.

80 tasks, 60 tasks and 40 tasks

Each of these tasks has its own parameters like deadline, priority, computational time, etc.

Initial population has been generated using the proposed algorithm randomly. The best fit values and solutions have been summarized below :

HBMO-random		
	objective Function	Computing time (ms)
40 tasks	1810	1786
60 tasks	6389	1875
80 tasks	11817	2754

Table 9 Results of simulation of Objective function along with time of computation for all the three cases.

Objective Function:

	HBMO-random	HBMO- Greedy Random adaptive search	HBMO-Hybridization
40 tasks	1810	1783	1745
60 tasks	6389	6438	6304
80 tasks	11803	11820	11542

Table 10 Values based Objective Function

Execution Time :

	HBMO-random	HBMO- Greedy Random adaptive search	HBMO-Hybridization
40 tasks	1776	1664	1382
60 tasks	1863	1269	2313
80 tasks	2765	2101	2680

Table 11 Values based Time of Execution

Our main goal is to select the best task scheduling approach in a real time approach. It has been worked upon this by considering two parameters which are objective function & time of execution. As per the results obtained the combination mating optimization of Honey bees along with hybridization is coming out to be better in case of objective function. Whereas in case of time of execution mating optimization Honey bees along with hybridization is better when number of tasks are less and Honey bees mating optimization along with Greedy random adaptive search is better when there are more number of tasks. If we find out the summarized scenario, then Honey bees mating optimization along with Hybridization is coming out to be better than other two approaches.

6. Conclusion

Through the sections of this paper, it has been tried to propose a solution of task scheduling problem in a system of real time. Many different algorithms have been merged in order to obtain the desired result. It has been tried generating the population using Random Honey bees mating optimization algorithm. Then IIt has been tried generating the same using the Greedy Random Adaptive search algorithm. Later , the Hybridization of random mating optimization of honey bees algorithm along with greedy random adaptive procedure have been realized and it found out to be the best solution. The solutions have been tested as well on some data. Only, in case Time is critical in scheduling then Greedy randomized search along with random honey bees mating optimization is best suited, but this compromises with other factors like cost ,run time and complexity.

7. References

[1] Yannis Marinakis1, Magdalene Marinaki2 and Nikolaos Matsatsinis1 , "**A Hybrid Clustering Algorithm based on Honey Bees Mating Optimization and Greedy Randomized Adaptive Search Procedure**", Decision Support Systems Laboratory, Department of Production Engineering and Management, Technical University of Crete, 73100 Chania, Greece.

[2] T. Chakaravarthy1* and K. Kalyani2, **"A Brief Survey of Honey Bee Mating Optimization Algorithm to Efficient Data Clustering**", 1A.V.V. M. Sri Pushpam College, Poondi, Thanjavur-6, Tamil Nadu, India

[3] Mohammad Fathian, Babak Amiri *, Ali Masoori, " Application of Honey bee Mating Optimization algorithm on clustering ", Elsevier, Iran University of Sceince and Technology.

[4]] Y. Marinakis, M. Marinaki and G. Dounias, "**Honey Bees Mating Optimization algorithm for large scale vehicle routing problems"**, Nat Comput, vol. 9, pp. 5–27, 2010.

[5] Application of Honey Bee Mating Optimization Algorithm to Load Profile Clustering Mihai Gavrilas, Gilda Gavrilas "Gh.Asachi" Technical University of Iasi Iasi, Romania, Calin Viorel Sfintes, EFE Energy Buzau n Buzau, Romania

[6] Shodhganga , Chapter -7 " A HYBRID GENETIC GRASP ALGORITHM FOR OPTIMIZING AOMDV ROUT.ING"

[7] Samir Kumar Singha and **Syed Imtiyaz Hassan**, **"Enhancing the classification accuracy of noisy dataset by fusing correlation based feature selection with k-nearest neighbour"**, Oriental Journal of Computer Science and Technology, vol. 10, no. 2, June 2017

[8] **Syed Imtiyaz Hassan, "Designing a flexible system for automatic detection of categorical student sentiment polarity using machine learning",** International Journal of u- and e- Service, Science and Technology, vol. 10, no.3, Mar 2017

[9] Greedy Randomized Adaptive Procedure. [Online].Available: https://en.wikipedia.org/wiki/Greedy_randomized_adaptive_search_procedure.

[10] Honey-bee-mating-optimization-algorithm .[Online]. Available: https://www.researchgate.net/figure/Honey-bee-mating-optimization-algorithm-11_fig1_230806696

[11] Drone mating with Queen bee. .[Online]. Available: https://www.pinterest.com/pin/354728908120122066/

[12] Tabu Search [Online]. Available: https://www.cleveralgorithms.com/nature-inspired/stochastic/tabu_search.html

[13] Simulated Annealing [Online].Available: https://en.wikipedia.org/wiki/Simulated_annealing