International Journal of Engineering & Technology, 7 (4.12) (2018) 26-29

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Hybrid Bat Algorithm for Balancing Load in Cloud Computing

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Abstract

Swarm Intelligence is proven to be beneficial for solving many problems including knapsack problem, minimum spanning tree, planning problems, routing, load balancing and many more. Here, the focus of the work is on bat algorithm. Due to astonishing feature of echolocation, bat algorithm has drawn researcher's attention in past years. It is applicable in solving different problems such vehicle routing optimization, time-tabling in railway optimization problems, load balancing in cloud computing etc. The main objective of this work is to propose a technique balancing the load among virtual machines in cloud computing environment.

Keywords: *Bat Algorithm, Cloud Computing, Load Balancing, Swarm Intelligence*

1. Introduction

Combinatorial Optimization problems involve finding a finite set of solutions among feasible solutions, which satisfy certain conditions. Combinatorial Problems are not only limited for finding shortest path in routing, for planning, scheduling and time –tabling in different optimization problems, but also applicable in various fields of engineering and other domains. Generating or finding exact solution for any of the above mentioned of problems is not only difficult, but sometimes seems to be un-realistic. To handle such type of problems, various swarm intelligence techniques have been proposed so far. These swarm intelligence techniques differ in the way of obtaining optimal solution, but share some similarity, which includes self organization, feedback either negative or positive, random initialization of variables used and mutual interaction. Here, broad categories of optimization techniques are described. Nature inspired approaches used for obtaining optimized results are categorized into following categories: evolutionary algorithms, physical algorithms, swarm intelligence, bio-inspired and other nature inspired algorithms [11]. To obtain optimized solution, Genetic Algorithm performs two operations, namely, crossover and mutation. Differential Evolution obtains the optimized solution of any problem by using a set of agents, also known as candidate solutions and generates new agents from existed agents. The generation of new agents is carried out using mathematical concepts. Depending upon the maximization or minimization function, selection of fitness value is done. If minimization function is applied, then the solution having minimum value is considered to be the optimal solution. If maximization function is applied, then the solution having maximum value is considered to be the optimal solution. The agents which satisfy these constraints are selected. Genetic Programming is one of the machine learning based technique which can be used for obtaining optimized solution from a given set of computer programs. The decision is based on the value of fitness function [1]. In Genetic Programming, calculation of fitness value relies on the ability of a computer program to execute the given task. Particle Swarm Optimization calculates the fitness value and updates the same of the feasible solutions, present in a search space, to obtain the optimized solution. Considering the behavior of cats, author of [4] has defined 2 modes, according to which cat swarm optimization works. These modes are: trace mode and seek mode. Cat Swarm Optimization is proven to beneficial for some problems. Another optimization technique is proposed, namely, Runner-Root Algorithm, inspired from runners and roots of plants. This Runner-Root Algorithm is used to solve various uni modal and multi modal problems. Another optimization technique which mimics the behavior of natural water drops, is proposed by the author. This approach is named as Intelligent Water Drop Optimization Technique. Ant Colony optimization is one of the famous optimization technique, which works by considering the pheromone produced by ants to share the information with other ants [6]. Considering the waggle dance of real honey bees, Karaboga has proposed an optimization technique and named it as Artificial Bee Colony. Under Artificial Bee Colony optimization technique, artificial bee's share the information with other artificial bee's using waggle dance performed by those artificial bee's. Echolocation is considered as one of the astonishing feature of real bats. Xin She Yang has proposed an optimization technique using echolocation as its major feature. The bat algorithm is proposed in 2010 [16]. Invasive Weed Optimization technique searches and finds most appropriate location for the growth and reproduction of weeds. Firefly's use their flash signal to communicate with other fireflies. Based on their communication process, author has proposed another optimization technique and named it as Firefly Optimization technique. Based on the breeding behavior of cuckoos of lying eggs in other bird's nest, inspired the author of [17] to propose an optimization algorithm on the same phenomenon. In Harmony Search optimization technique, numerous musicians play note together in order to achieve global optimal solution. Artificial Fish Swarm optimization technique is proposed, considering the collective movement behavior and social behavior of fishes [12].

Various researchers have contributed in the field of optimization either by improving the performance of existing techniques or by

proposing hybridized algorithms. But still, there is a scope of improvement in each and every technique for obtaining more optimized results. In this research work, main focus is on the hybridization of Bat Algorithm with other techniques available to generate more optimized solution. Different variants of Bat Algorithm covers three major processes: Intensification and diversification process, Initialization process and Updation of parameters process. Here biological behavior of real bats is explored to develop another variant of Bat Algorithm to achieve more optimized results. The broad categories of optimization techniques are depicted in figure 1.

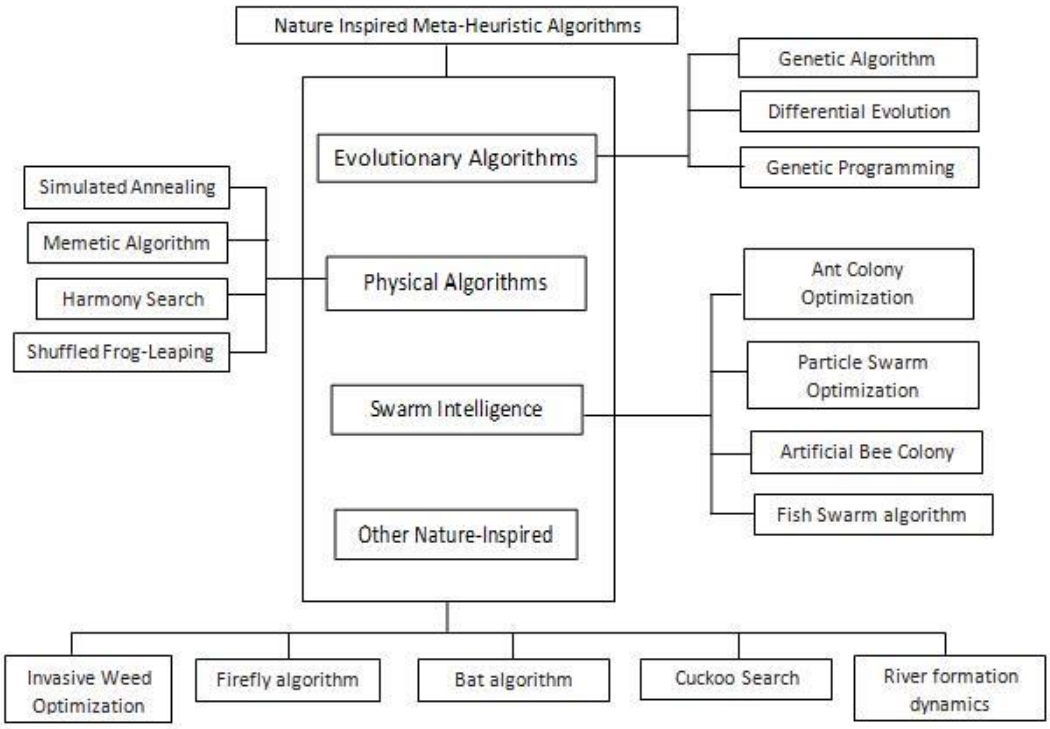

Fig. 1: Nature-Inspired Techniques for Optimization

2. Standard BAT Algorithm

Echolocation feature of real bats has motivated the author to propose a new optimization technique in order to provide solutions to different types of engineering, mathematical and combinatorial problems in 2010 [16]. In the research paper [16], it has been suggested by the author to consider given parameters: frequency, position, pulse emission rate, loudness and velocity, in order to select best or optimal solution among available feasible solutions. As the bat approaches target, bats start emitting pulse at faster rate and loudness of the pulse emitted is reduced, so that target should not be able to hear the sound. Considering these facts about real bats, author has proposed artificial bat algorithm for optimization. This is also known as Bat Algorithm or Standard Bat Algorithm. The pseudo-code of Bat Algorithm is depicted in figure 2.

Bat algorithm is mostly used for solving variety of problems, which may be complex in nature, as bats possess the ability to change its state very quickly from intensification (exploration) to diversification (exploitation). Sometimes, bats stuck in local optimal solution obtained, due to the quick transfer from from intensification (exploration) to diversification (exploitation). To avoid trapping in locally obtained optimal solution, many researchers have proposed various variants of bat algorithm. The main concern of Bat algorithm variants is on three areas: intensification (exploration) and diversification (exploitation) process, initialization and updation of parameters. Biological behavior of real bats is explored to achieve more optimized results, in the next section.

3. Biological Behavior of BATs

Bat adjusts its parameters, including, frequency, velocity, position, pulse emission rate and loudness according to the movement adopted target. Real bats will in three different phases: search phase, approach phase and terminal phase. Updation of these factors will differ from one phase to another. It means that, the values substituted for search phase will be different in approach phase. Similarly, values used for approach phase will differ from tracking phase. And same thing implies for tracking phase values to terminal phase values. During echolocation, bats generally produced two types of signals, i.e. narrowband and broadband. These signals are further categorized into two categories, one which have frequency modulation & another which have constant frequency and named as Frequency Modulated Signals and Constant Frequency Signals. Bats generally produce sound in these two types, either frequency modulated or constant frequency. To decide, which signals bats will produce, will depend upon, what kind of information/message the bat wants to know about the surrounding. To determine the distance between itself and target, frequency modulated signals are produced by bats, whereas constant frequency signals are used for detecting target present at far distance and also for detecting the movement of targets [10]. In order to prevent the overlapping of pulse emitted and received echo, real bats generally reduce the duration of frequency modulated signal. Sometimes, pulse emission done by multiple bats at the same time, will lead to the interference of signals due to this crosstalk problem. To avoid such situation, real bats cease the vocalization and fly in silent mode [2]. While shifting from one (vocalization) mode to another (silent) mode, relative positions of bats play a major role. When real bats are in silent mode, without emitting pulse and receiving echo, bat which is in silent mode, can still obtain the information about target's location. Using this information, bats avoid collisions. Bat search space can be considered as depending upon the search cone angle which is formed from the head of bat. To have larger search space, angle should be larger and larger the search space, chances of having more feasible solutions. Bats have the capability to identify different category of targets, using echolocation. Bats can also determine the different parts of complex target, which may be located at different distanc-

es [15]. Bats can even calculate variation in delay's, before making the decision regarding, which prey to capture. Bats generally adopt different flight behavior's, which are mentioned in [6]. Bats have the capability to detect the presence of target, can extract the information about the exact location, even in the presence of background noises [10]. To separate the received echo from noise, many factors are considered, which include source level, target strength, transmission losses, level of noise, directional index value and directional threshold's. Depending upon the differences that exist in spectra of echo, shape and kind of target, bats can discriminate between different categories of targets'. Bats obtain the information about the size of the object, shape of the object and surface properties of the object from the temporal and spectral elements of echo received.

Algorithm 1: BAT Algorithm

Data: Initialize bat population position x_i,
velocity v_i, pulse rate r_i, loudness a_i
and frequency f_i.
Result: Optimized Solution
Begin
Set maximum number of iterations
and represent it using max.
while (curr_iter<max)
Generate new solutions by adjusting position,
Frequency and velocity
If (rand > r_i)
Select best solution among all solutions
Generate a local solution around the selected best solution.
End if
If ((rand < a_i) && (f(x_i) < f(x^*))
Accept new solutions and
Increase r_i and reduce a_i.
End if
Rank the bats and find the current best solution, x_i.
End while
Post-process the results.
End

Fig.2: Pseudo Code of Bat Algorithm

4.
Echolocation feature holds a lot of information, which include distance between prey and bat, angular direction and target (prey) size. Researchers can work on the inclusion of such features of real bat, to develop new variants of bat algorithm. However, attenuation affects the loudness, pulse rate emission and echo produced by bats. To test the feasibility of newly developed variant of bat algorithm, application areas like vehicular ad hoc network, cloud computing, training of feed forward neural network, solving ergonomic work place problems, classification of gene expression data, job scheduling in cloud computing environment, can be considered. In this work, an algorithm is proposed to balance the load among virtual machines present in cloud environment.

5. Load Balancing in Cloud Computing

Cloud Computing works on the basis of pay-per-use concepts. It is beneficial to the users, in terms of cost and availability of resources. While opting for cloud services, many factors are considered, as cloud environment has many challenges, including security, resources, availability, load balancing, job scheduling and many more. This work primarily focuses on load balancing in cloud computing environment. In previous decade, different techniques are proposed for balancing the load in cloud computing environment are proposed which focuses on either reducing the response time or increasing the availability of resources or ensuring the secure environment. But still, research is going on in different aspects. In [7], fuzzy based load balancing technique has been proposed by the author. A review of various nature inspired techniques has been reviewed by the author in [9], which have been used for scheduling the jobs in cloud. Ant Colony based load optimization technique has been proposed by the author in [5]. Artificial Bee Colony based load balancing technique is proposed in [13]. For scheduling the jobs in cloud, author has applied bat algorithm for obtaining optimized results [14]. Here, the focus is on the development of load balancing technique in cloud computing.

6. Proposed Algorithm for Load Balancing in Cloud Computing

In Cloud Computing, proper allocation of resources to the tasks and selection of appropriate virtual machines are one of the major challenges. Before assigning the jobs to the available virtual machines, resource required for each job execution and available resources, i.e. available virtual machines, should be considered prior to the selection of the best virtual machine. Whenever any virtual machine is under-loaded or over-loaded, load balancer should migrate the jobs for execution from one virtual machine to another virtual machine. In this research work, for the allocation of the jobs to optimal virtual machine, hybridized Bat algorithm is applied, which is the combination of bat algorithm along with tabu search technique. To ensure that the same virtual machine should

not be visited again, while balancing the load, tabu search is used. For the same, two lists are maintained, one is non allowed list and another is allowed list. In the hybrid bat algorithm, jobs will be treated as artificial bats and virtual machines will be considered as target. The hybrid bat algorithm offers better exploration and diversity of search space, by avoiding visiting the same solution again. The steps of proposed algorithm are given below:

STEP 1: Initialize the parameters of bat algorithm, i.e. position, loudness, pulse emission rate, loudness and velocity.
STEP 2: Initialize the available Virtual Machines VM_i which consists of VM_1, VM_2, ……, VM_n
STEP 3: Input the jobs, user wants to execute, Job J_i which comprises $\{J_1, J_2, \ldots\ldots J_n\}$ jobs.
STEP 4: Identify the resources required for the execution of the jobs are represented as RR_i.
STEP 5: Consider RA_i as the set of resources available in VM_i.
STEP 6: Let the artificial bats to select the optimal virtual machine which fulfill the job requirements, using standard bat algorithm.
STEP 7: With the use of Tabu Search, neighbors of selected virtual machine will be blocked for current iteration. These set of VM_i are known as Non Allowed set, while others are considered as allowed set of virtual machines.
STEP 8: Repeat the process to select optimal virtual machine for each job execution.

Algorithm 2: Load Balancing Algorithm

Data: Set VM_i as group of Virtual Machines.
Set T_i as group of Tasks to be executed by VM_i.
RA_i and RR_i represent resources availability and resource requirements of VM_i and T_i respectively. **Result:** Optimal Selection of VM
Begin
Apply bat algorithm to select appropriate Virtual Machine VM_i for the execution of Task T_i.
Use Tabu Search to avoid the use of neighbors of selected VM_i.
In case of under-load and overload of VM_i, set Non-Allowed Set = $\{VM_{i-1}, VM_{i+1}\}$ and remaining virtual machines are said to be in allowed set.
End

Fig. 3: Load Balancing Algorithm

7. Conclusion & Future Scope

Bat algorithm has gained popularity in last few years, as it is applicable in almost every field for solving and obtaining the optimized solutions to the problems, including training of neural network systems, solving work place problems, classification of data, job/task scheduling in cloud computing environment and many more engineering and mathematical problems. Echolocation not only allows bat to locate and identify the target (prey), but also helps in identifying the size and shape of the target. Various features of real bats can be explored to develop more variants of bat algorithm.

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