Literature Review of Nature Inspired Computing Based Search & Optimization Approaches

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***Abstract*—** Nature is the great source of knowledge. It is the best example to solve very complex problems with great simple manner. Nature inspired computing (NIC) techniques are inspired by elements and processes, observed from nature. These computing techniques attracted the researchers to develop the various nature inspired techniques to solve the complex problems. This paper presents a state of the art review of nature inspired computing based search & optimization algorithms. In this paper we categorized the nature inspired computing based search and optimized algorithms in four categories i.e. swarm intelligence based algorithms (SI), Bio-Inspired (Non-SI) algorithms, Evolutionary Computing Algorithms and Physics and Chemistry based algorithms.

***Keywords*—** *Nature Inspired Computing, Search & Optimization Algorithms, Swarm Intelligence, Evolutionary Computing*

I. INTRODUCTION

Nature-based Computing (NIC) is powerful mechanism or discipline that can be used to develop new and innovative computing techniques by observing natural-occurring phenomena to solve computing-related complex and composite problems in various environmental situations. The techniques that come under NIC approaches are highly applicable in the fields of engineering, physics, biology, agriculture, education etc.

Since science is a sub-part of nature. So, directly or indirectly we can solve the NP-hard problems with the help of nature processes. In this survey we categorized the Nature-based computing approaches into different varieties like- Swarm Intelligence Based Approaches, Bio-inspired Non-SI Approaches and Evolutionary Computing Based Approaches.

II. SWARM INTELLIGENCE BASED APPROACHES

Swarm insight originates from imitating nature. Swarms of social creepy crawlies, for example, ants and honey bees, work utilizing an aggregate knowledge that is more prominent than any individual from the swarm. Swarms are thusly exceedingly successful critical thinking bunches that can without much of a stretch manage the loss of individual individuals while as yet finishing the main job - a capacity that is extremely attractive for countless. This paper provides with the depth survey of some of the well-known optimization algorithms.

Ant Colony Optimization algorithm (ACO) [1] is a nature inspired mechanism which has been inspired by the journey of ants to search food with the shortest path. These ants drop pheromone on the ground to mark some supportive ways that should be followed by its peers to reach to the food. The ants travel from one location to another and when the optimum path or shortest path is discovered they release the pheromone. The shortest path followed by each ant strengthens the path using pheromone thus resulting in solving optimization problems. Several other authors [2] have discussed about the different algorithms taking ACO as a base one. A comparative study done by Stephen et. al. on the Ant Colony optimization Algorithm along with some other algorithm like Ant System, Ant Colony system, Max-Min Ant System, Rank- Based Ant System and other ACO organization [2]. The performance of Max-Min Ant [3] System works only for the best solution that increases the value of pheromone value during its trial update.

Firefly Algorithm [4] is based on the behavior of the Fireflies including their way of blazing and attracting their mates which display the method for resolving the bound constrained optimization problems. The authors have proposed a method to change the attractiveness function of these Fireflies using two approaches in which one of the approaches uses a numerical experiment planted to do calculate the distance between two subjects in order to improve the productivity and firmness of FA. The second approach refers to the two new functions for attractiveness Beta 1 and Beta 2. To show the attainment of the proposed modified FA, the author used an array of benchmark global optimization test problems. When compared with the original FA,the modified FA revealed emulous results. As a future work, this algorithm can be extended to resolve strained problems, stationed on penalty techniques.

According to Mei-ping song [5] survey, PSO converges first and somehow its efficiency leads some problems, such as local optimization caused by premature and optimal ability dependent on parameter setting. So much work has been done on Parameter Modification and Diversity

Increase. Hemalata and Professor Rahila Patel [6] reviewed their paper on PSO in single and multi objectives optimization. The PSO algorithm, is based on the flocks of birds where the population either goes in a group or are scattered in the search of food. Each particle uses certain value while looking for food. The pbest value is a value in which the particle keeps a record of its coordinates. Another value is lbest that tracks the value of the neighbors as a topology. Further the author has mentioned that PSO helps in solving multi objectives problems and several latest proposals have been made to extend PSO to handle multi objectives. In the paper, experimental work has been done to solve multi objective optimization problem has been define by using Dynamic PSO. The experiment tries study the behavior of PSO in 2 and 10 dimensional spaces. The simulation results proved that PSO works better in 2 dimensional spaces whereas in 10 its performance is degraded.

EEL'S ALGORITHM (ELA) [7] is based on the migration behavior of eel's. The algorithm is based on three important behaviors of eel:- the density adaption, the neighborhood learning and sex mutation. The authors have reported that how eel's adapted the changes of the environment and can adjust their sex in the extreme climate. The proposed algorithm was tested on several benchmark functions and was compared with GA and PSO. Although the results of ELA are not good for some of the functions, but it is proved to be better as compared to GA and PSO.

Cuckoo Search algorithm [8] is based upon the behavior of Cuckoo birds. As they are acclaimed for wonderful sounds they make, they have one greater nature of forceful propagation methodology. The cuckoo winged animals lay its eggs in the home of different flying creatures as they don't have the usefulness of bring forth. So to increase the reproductively the hatching process is done by the host bird in which the eggs are layed. Based on this approach, the cuckoo search algorithm has 3 idealized rules. These tenets incorporates that each cuckoo lays one egg at any given moment and picks an arbitrary home to dump them. The second rule says that among those randomly chosen nest, the one with the high quality collection of eggs will carry over the next generation. In the last manage, the amount of accessible host homes is settled and if the host winged animal finds the eggs laid by cuckoo, it is possible that they will make another home or will discard the eggs.

Most of the swarm intelligence technique that are used to solve the optimization problems cannot have the leader to control over the entire period. This drawback is rectified in Grey Wolves Optimization GWO algorithm [9].In this approach the grey wolves have natural leadership mechanism. The proposed algorithm is based upon the hunting behavior of the wolves. The alpha wolves are leaders of the pack and they are male and female. They considered the dominant wolf in the pack and all their orders should be followed by pack members. Alpha's are responsible for decision making about everything. The hierarchy is then followed by Beta Wolves which are considered as the best candidate to be alpha, when alpha passes away or becomes old. The beta fortifies the apha's orders all through the pack and gives the input to alpha. After beta, there are delta wolves considered as subordinates. They have to submit themselves to alpha and beta but they dominate the lowest level wolves in social hierarchy and they are known as Omega. Omega are considered as substitute in the pack and are the last enabled wolves to eat. In the GWO, the fittest solution is considered as alpha followed by beta and delta. During hunting process the grey wolves encircle the prey and this is how their search is completed.

Bee colony optimization algorithm [10] is very popular swarm intelligence based search and optimization algorithm. In this algorithm the bees search their food by forming a local optimized solution. The proposed algorithm is a specialization to swarm intelligence where the bees communicate with its peers by a strategy known as Waggle dance and exchange the main information with the rich quality foods by defining the location of the sources.

Artificial Bee colony calculates finds the great nectar source as indicated by the data transmission and shared participation among people in the province. About this sort of honey bee state calculation, the high quality nectar source speaks to the ideal arrangement. Each laborer who leaves the swarm to locate the nectar source speaks to a doable arrangement.

The BCO differs from ABC as they only use scouts and forages in equal proportion to queen, male and female bees in BCO. The author talked about different application where the bee colony algorithm was tested such as in MANETs routing protocol, sudoku problems that are based on NP hard problems. Another application includes problem solving mechanism.

BAT algorithm [11] is based on the behavior of bats based on the echo location feature of them. BA utilizes a recurrence tuning method to increase the diversity of solutions and in the meantime to balance the exploration and exploitation during search process; it uses automatic zooming to figure its distance from prey. The loudness of bat and pulse emission variation rates proves to be very efficient for a speedy begin. The author has described the bat algorithm on 3 important rules:

(a). Bats use echolocation to measure the distance. Somehow they know the gap between food and prey including backend barriers.

(b). Bats fly randomly and can adjust the frequency of emitted pulses based on their target.

(c). Loudness may vary from last two minimum values. In bat motion the loudness and pulse emission provides a

mechanism for automatic control and zooming with optimum solution.

The BA algorithm provides a key advantage that at a very early stage it converges quickly from exploration to exploitation that makes the algorithm even more efficient. When the accuracy and efficiency of BA was compared to ABC, hybrid genetic algorithm [12]. It was concluded that BA was much more easy and superior to implement. As concluded by the author, the convergence speed of algorithm is still challenging and its improvement and enhancement can be done as the future work.

Paddy field algorithm (PFA) is a new biologically inspired swarm intelligence algorithm. It operates by scattering seeds randomly at an initial stage in a defined parameter space. The seeds that falls into fertile soil tends to grow and produce more amount of seeds. These tallest plants would correspond to optimum condition. The other main factor that affects the reproduction is pollination. Meaning the higher the density of plants the more chance of pollination. Paddy field algorithm has 5 stages that produce different functions in each stage. The cycle incorporates the following stages:-

1. Sowing :- This is the initial stage in which seeds are sown aimlessly in the parameter space. Keeping in mind the end goal to guarantee ideal scattering inside the parameter space, the estimations of seed measurements are consistently disseminated relying upon the limits of the parameter space.
2. Selection:- After the seeds are sown into the field and deliver plants, the best plants are chosen relying upon a edge strategy. This is to specifically get rid of ominous arrangements. The purpose behind having a limit is to guarantee that the plant populace does not develop dangerously.
3. Seeding:- The threshold administrator (H) is utilized to choose various plants from the populace for the following cycle. The fundamental reason for this is to control the number of inhabitants in the framework.
4. Pollination:- pollination which totally depends on the number of neighbors. More neighbors more plants will be.
5. Dispersion:- where the cycle again begins. The seeds are scattered in the last stage.

The PFA algorithm is tested against different other algorithm for 4 functions.
Function 1: It has global maximum along with a series of local maximum ridges characteristics
Function 2: Has 2 optimum solution for global and local maximum at (0.5,0.5) where global maximum uses
a small area to fool on optimization algorithm
Function 3: has 8 local maxima and global and is adaptive from Rastigrin function.
Function 4: It is adaptive from Rosenbrock function, has a flat region in vicinity of global maxima.

When PFA compared with these functions along with GA, it proved to be more efficient. The PFA does not form any crossover like GA. Coupling of HCA + PFA will enhance its performance. The Hill Climbing Algorithms (HCA) [13] among the most punctual calculations for enhancement and are vigorously dependant on the underlying qualities. On the off chance that the underlying quality is found in the region of a nearby arrangement, the calculation is well on the way to stall out at this undesired arrangement. Hence optimal solution is not capable of migrating in same manner as in GA. PFA solves the main problem of HCA by randomly selecting sample points in a particular area by checking the fitness of each population. But somehow due to lack of crossover like in GA, the optimal solution is incapable of migrating. So to solve this a hybrid approach is tested using HCA and PFA for final convergence.

III. BIO INSPIRED NON-SI APPROACHES

Many algorithms of Bio-inspired category are not directly connected with swarm intelligence, so we usually called these kind of algorithms as Bio-inspired but non-SI based. In this paper we have discussed some of the Bio-inspired and Bio-inspired non-SI based algorithms.

In 2013, "Xin-She Yang" has proposed flower pollination algorithm [14]. This algorithm is influenced from the pollination process of flowers. To check the validity of this new algorithm the researcher had performed ten test functions. The performance results of the algorithm are very effective. The results showed that the proposed approach is more efficient and effective as compared to genetic algorithm and PSO algorithm as its convergence rate is relatively high.
Hernández et. al. proposed Japanese Tree Frog Calling algorithm [15]. The proposed algorithm is inspired by the Japanese tree frogs calling behavior. Female frogs are attracted by the calls of male frogs. Surprisingly, in the common local area the group of males frogs desynchronize their calls. Due to this reason the female frogs can locate the male frog. This new algorithm uses this desynchronization of calls behavior to allocate the colors to adjacent nodes. The authors have given the solution to solve the problem of coloring graph nodes. The authors have introduced the algorithm which uses the local data for selecting the colors of all adjacent nodes of a graph.

In Biogeography based Optimizationthe author has discussed the way to solve the optimization problems by using the natural biogeography and its mathematics [16]. The researcher finds that this algorithm is having characteristics to solve the high-dimension problems. It is also having some other incomparable properties to give the optimal solution. The performance of BBO is evaluated by comparing it with other seven biology- based optimization methods.

In 2014, "Lenin, Reddy and Kalavathi" proposed the Dolphin echolocation Algorithm (DEA) for giving the solution to power dispatch problem [17]. Authors discussed the echolocation process which helps the dolphins to find out the different locations. Dolphins are capable to produce one sound of click. When this click sound hits the object, some of the sound-waves reflect back to the dolphin. Instantly one echo sound is received and dolphin produces another click. The time gap between the click sound and echo sound helps the dolphin to calculate the distance from the object. In this paper DEA algorithm is implemented to design a new process to solve the optimal reactive power dispatch problem.

In 2013," Yan GW, Hao ZJ" have presents the new bio inspired algorithm called Atmosphere Cloud Model Algorithm. The algorithm is influenced by the basic nature of clouds[18]. The atmosphere clouds model optimization (ACMO) algorithm is used to solve the optimization problems. The researchers have tested this algorithm on a set of benchmark functions. The performance result of the algorithm was also compared with other recent algorithms. The authors have also tried to replicate the behavior of clouds (generation, move and spread) in more easy way.

Fish School Search algorithms by proposed in [19]. This algorithm is inspired by the food finding process of fishes. Fishes have the capability to find the area of more nutrients. This can be done individually or by the groups of fishes. Thus, the area with more number of fishes will be the most nutrient place. By considering this behavior of fishes, this algorithm divides it into three different kinds like prey, swarm and follow. Prey is biological nature that helps the fishes to find food. Under swarm behavior, fishes are mostly travelled in groups. The third kind of behavior tells the way in which one or group of fishes find the food area and others follow the same path and find the food rapidly.

Sung Hoon Junget. al. proposed a new queen bee evolutionary algorithm [20].The proposed algorithm is basically influenced from the queen bees, which are very important for the reproduction life cycle. In this we find the fittest value from individual generation and then cross breeds it with other selected parents bees. The selection of parent bees is done through a selection algorithm. The researchers have done some experimental work to increase the exploitation and exploration of genetic algorithms.
Brain Storm Optimization Algorithm [21] intimidates the human brainstorming process. Usually, we all encounter some kind of problems which cannot be solved by a single person but a group of people with different mindsets or different skills, collectively solve the same problem, more accurately. The author has tested the performance of proposed algorithm by using two benchmark functions.

Eusuffet. al. have introduced a new shuffled frog-leaping algorithm (SFLA) to solve combinatorial optimization problems. It is inspired by natural memetic. This algorithm has the capability of local search to global optimization[22].

Human-inspired algorithm (HIA) was introduced in [23].The authors presented the algorithm to solve the non-linear problems by giving more optimal solutions from given set of population. HIA follows the behavior of mountain climbers for searching the highest mountain in the particular area by using modern tools. According to the testing of this novel algorithm, the researchers claimed the better and effective result in the comparison of GA and BA.

IV. EVOLUTIONARY COMPUTING BASED APPROACHES

Evolutionary Computation is the part of the global optimization algorithms which is inspired by biological and genetic evolution. With respect to the biological world, a population of desired solutions is subjected to artificial or natural selection and mutation. Gradually, the population will evolve to fitness which in turn helps to select the fitness function of the algorithm. The techniques of Evolutionary Computation produce the optimized solutions to the various problems of computer science, which in turn, makes it popular in the computing world.

Holland JH has proposed Genetic Algorithm in [24].. The author in [25] explained that GA can be referred or included as one of the sub-topic of the Evolutionary Algorithm. It is a probabilistic search algorithm that is based upon the natural selection and natural genetics. A genetic algorithm is one of the search technique used in computing world to find approximate or exact solutions for optimization and search problems. At each generation of the whole population, the chromosome which is fit is being evaluated and then chromosomes of the next generation are probabilistically selected for the mutation based upon the fitness status. It has been used widely in various domains such as engineering, computer science etc to solve and find out the optimal solutions for the complex problems. The author wants to suggest that this algorithm can be utilized for optimization problems of the computing science world like scheduling, shortest path etc. This algorithm provides a technique for the computer program to improve and detect the parameters automatically.

Daan Wierstra and his team have discussed the natural evolution strategies algorithm in [26]. In Evolution Strategies, mutations are generally done on the basis of specific mutation sizes. The main concern in this algorithm is the mutation sizes. The author points out the automated adjustment of the mutation sizes of a particular population. The samples of the mutation sizes of a particular generation should be selected wisely, neither it should be too high nor it should be too low. The author proposes that it has been inspired from the Natural Darwinian Evolution. A batch of samples is mutated by using a sexual reproduction. From here, a batch of samples is selected based upon the fitness value, while the less fitted individuals are discarded. The

winners are then mutated with the next generation and so on.

Differential Evolution was proposed by [27]. Swagatam Das et. al. discussed Differential Evolution [28]. The author wants to say that instead of creating new offspring from traditional crossover or mutation, new offspring can be generated from parent chromosomes. It can be used to maintain a population of candidate solutions for optimizing a problem. Later on, creating unique and new candidate solutions by combining existing ones and so on. This process goes on, to find out the best or fitness candidate solutions which can be used and utilized for optimization problem.

Genetic Programming was proposed by Koza JR [29]. Pedro G. Espejo et. al. discussed Genetic Programming approach[30]. The author suggests that Genetic Programming is an evolutionary learning technique which can be used widely in the computing world for classification. Being the heuristic technique of evolutionary computing, this technique can be used for complex pattern representation, such as trees. Here, computer programs are encoded as a set of genes which are then modified to generate the fittest genes in the form of computer program.

Martin V. Butz has discussed Learning Classifier Systems (LCS) [31]. The LCS is one of the machine learning algorithm that combines evolutionary optimization. It can be successfully applied to the various fields or domain like data mining, cognitive map learning and reinforcement learning to solve various problems related to these domains. The final or desired outcome of running the LCS algorithm is for those classifiers for collectively modelling an intelligent and unique decision maker [32].

Shakti et. al. proposed a new multi-population based global optimization algorithm called Parallel Three Parent Genetic Algorithm algorithm (P3PGA) [33]. P3PGA is multi-population algorithm. In this algorithm multiple populations works in parallel manner to find out the global optimum solution. P3PGA extends the working of Genetic algorithm by correcting the mitochondrial diseases in population. This attempt is made to achieve and produce healthier offspring as compared to genetic algorithms.

Qingfu Zhang et. al. presented the Estimation Of Distribution Algorithms (EDAs) [34]. It can also be termed as probabilistic model-building genetic algorithms. The main mechanism of this algorithm is to extract globally statistical information from the selected solutions. A new model with these solutions is built and replaces the old population so as to produce a new solution which will be much more fit in the environment. It is an interesting and efficient tool for the researchers to provide adequate solutions those who are working in the field of evolutionary computation as well as for the engineers or developers to provide solutions who face real-world optimization problems.

V. PHYSICS AND CHEMISTRY BASED ALGORITHMS

Galaxy-based search algorithm has been proposed by [35]. The author stated that this algorithm can be used to search for the optimal thresholds in the spiral arms of some galaxies. It has been mainly introduced for the concept of multi-level thresholding. It is also known as “GbSA-MLT”. From the initial solution, this algorithm moves spirally to search the surrounding of the core until and unless it finds out a suitable and appropriate solution.

Rabanal P and his team proposed the River formation dynamics algorithm [36]. This algorithm focuses on providing some advantages over various methods like ACO (Ant-Colony Optimization) methods. This algorithm can be used in TSP (Traveling Salesman Problem). When any water mass is created at some high point of mountain due to rain, those water tries to get connected with the water bodies like sea. When these water travels down to the surface, eventually creates a river-bed. Based upon this idea, this algorithm has been presented to the computing world.

Harmony Search has been proposed by Geem ZW et. al. [37]. The main mechanism that is being used in this algorithm is the music harmony. Music harmony is a combination of sound considering a pleasant and soothing environment. The set of sounds can be used for an aesthetic estimation. This idea gets integrated in Harmony Search (HS) for solving the optimization problems.

Erol OK, Eksin I. has proposed the BB-BC (Big Bang-Big Crunch) Algorithm [38]. It is evolved based upon the theory of the evolution of the universe called Big Bang-Big Crunch Theory. Here, the candidate solutions are spread all over the search space in an uniform manner. The main feature of it is that randomly distributed particles are drawn into an order.

Shakti Kumar and his team proposed the Parallel Big Bang-Big Crunch Algorithm [39]. This algorithm overcomes the existing BB-BC (Big Bang Big Crunch) algorithm. It is the modified version of BB-BC algorithm. It implies to use more than one or more populations. At a particular time, initially, the search starts independently for all the population in parallel. As the search continues, the algorithm detects and determines the local best and fittest of each individual population to interact with the global population. It is mainly implied for multi-population algorithm.

Kumar S, Singh A and Walia S. proposed a PB3C based new routing mechanism for WMNs (Wireless Mesh Networks)[40]. The mechanism of such invention is to find

out the near shortest path route. The approach was carried out and simulated by using the software called MATLAB.

CONCLUSION

This paper categorized the nature inspired search & optimization approaches into 4 broader categories. These 4 categories consists the algorithm based upon the swarm intelligence, Algorithms based upon the non swarm bio inspired intelligence, Evolutionary algorithms and the algorithms based upon the physics and chemistry approaches. In this work we performed an extensive survey on recent nature inspired computing approaches.

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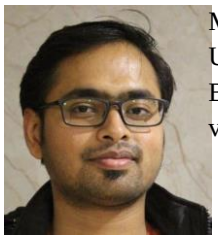

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