A LITERATURE BASED SURVEY ON SWARM INTELLIGENCE INSPIRED OPTIMIZATION TECHNIQUE

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ABSTRACT

Nature is of course a great and enormous source of inspiration for solving hard and composite problems in the field of computer science, transportation engineering, mechanical engineering, management and so on, since it exhibits exceptionally diverse, dynamic, robust, and complex phenomenon. It always finds the optimal solution to resolve its problem establishing perfect balance among its components. This is the driving force behind bio inspired computing. Nature inspired algorithms are meta heuristics that mimics the nature for solving optimization problems thus opening a new era in computation .For the past decades ,numerous research efforts has been concentrated in this particular area. Still being infantile and the results being very astonishing, broadens the scope and feasibility of Nature Inspired Algorithms (NIAs) exploring new areas of application and more opportunities in computing. This paper highlights the comparative analysis of nature inspired swarm Intelligence based optimization techniques based on literature analysis and the areas where these algorithms have been most successfully applied.

Keywords*: *Nature Inspired Algorithm, Optimization technique, Swarm Intelligence

I. INTRODUCTION

Every one of us experiences the magnificence of nature. The way it is constructed and managed scientifically is appreciable. However, the complexity beneath it is extremely difficult to understand. For example, functioning of brain and its communication with different parts of the body, relocation of birds every year from one subcontinent to the other and evolution of nature and human being, everything looks incredible and wonderful but simple. In reality, the so-called simple nature is very much complex. Technological advancements provided us with computers to carry out complex tasks. Therefore, if the computers are competent of performing tasks with reasonable degree of complexity, why cannot we take inspiration from nature and mimic it to solve some of the complicated problems that are hard to solve? The answer to this question is yes. It is possible but it is very difficult to mimic nature since nominal information is available in direct form. In spite of these technical hitches, researchers have tried to connect the nature with computation and the nature-inspired algorithms have resulted as an outcome of some of the finest research work. This paper discusses the classification of set of nature-inspired algorithms particularly brief explanation of swarm based algorithm.

II. CLASSIFICATION OF NATURE INSPIRED ALGORITHMS

Nature presents many diverse phenomenons. These can be transformed into mathematical algorithms, which, formulates to mathematical algorithms. However, based on the applicability some of these algorithms have reached a stage of development while some are still in the intangible phase or in a situation where the application mapping is not found. Nature inspired algorithms are broadly categorized into four categories based on the fundamental natural process that they possess : swarm intelligence (SI) based, bio-inspired (but not SI-based), physics/chemistry-based, and others. However, we will focus here on swarm intelligence (SI) based algorithms.

It is worth pointing out the classifications here are not distinctive as some algorithms can be categorized into different categories at the same time. The categorization depends on the real perspective and inspirations. Therefore, the categorization here is just one probable attempt, though the stress is placed on the sources of inspiration.

2.1 Swarm intelligence based

Swarm intelligence (SI) concerns the cooperative, promising performance of multiple, interacting agents who follow some plain rules [1]. While each agent may be measured as unintelligent, the whole system of multiple agents may show some self-organization performance and thus can behave like some sort of cooperative intelligence. Many algorithms have been developed by drawing inspiration from swarm-intelligence systems in nature.

All SI based algorithms use multi-agents, inspired by the cooperative actions of social insects like ants, bees, as well as from other animal societies like flocks of birds or fish. A list of swarm intelligence algorithms and there principle is grouped in Table 1.

SI-based algorithms are amongst the most accepted and extensively used. There are several reasons for such recognition; one of the reasons is that SI-based algorithms usually shared information among multiple agents, so that self-organization, co-evolution and learning all through iterations may help to provide the high efficiency of most SI-based algorithms. Another reason is that multiple agent can be parallelized easily so that large extent optimization becomes more realistic from the implementation point of view.

2.2 Bio-inspired (not SI-based)

In true sense, bio-inspired algorithms form a popular of all nature-inspired algorithms. From the set theory point of view, SI-based algorithms are a subset of bio-inspired algorithms, while bio-inspired algorithms are a subset of nature-inspired algorithms [1]. That is

$$\text{SI-based} \subset \text{bio-inspired} \subset \text{nature-inspired}$$

On the other hand, not all nature-inspired algorithms are bio-inspired, and some are wholly physics and chemistry based algorithms as we will see below. Many bio-inspired algorithms do not use directly the swarming behaviour. Therefore, it is better to call them bio-inspired, but not SI-based like Invasive weed optimization, Paddy Field Algorithm, Flower pollination algorithm etc.

2.3 Physics and Chemistry based

Not all algorithms are bio-inspired, since their sources of inspiration often come from physics and chemistry. For the algorithms that are not bio-inspired, most have been developed by mimicking certain physical and/or chemical laws, including electrical charges, gravity, river systems, etc. As diverse natural systems are relevant to this category, we can even subdivide these into physics and chemistry based algorithms.

2.4 Other algorithms

While researchers develop new algorithms, some may look for idea away from nature. As a result, some algorithms are not bio-inspired or physics/chemistry-based, it is sometimes difficult to put some algorithms in the above three categories, because these algorithms have been developed by using various characteristics from diverse sources, such as social, emotional, etc. In this case, it is better to put them in the other category.

III APPLICATIONS

Nature Inspired Computing techniques are so elastic that they can be applied to broad range of problems, so flexible that they can deal with undetected data and capable of learning, so robust that they can handle imperfect data.. There are three key differences between conventional computing systems and biological information processing systems: components of biological systems react slowly but implement much higher-level operations. The capacity of biological systems to assemble and develop on their own enables much higher interconnection densities. The implementation of biological systems is not a premeditated one.

One who wishes for solutions from nature for complex problems has to first examine the nature's behaviour cautiously. The subsequent step is to use models and record all the behaviours observed so far. The above steps should be repeated till an ideal operational model is obtained. As a by-product some unidentified mechanisms may be found. Based on the examination from nature a problem-solving strategy is formulated. Two main computational applications of NIC are Clustering and Optimization.

3.1 Clustering

Clustering is the unverified categorization of patterns into groups (clusters). An explanation of clustering could be the method of organizing objects into groups whose members are similar in some way. A cluster is therefore a group of objects which are "similar" among them and are "dissimilar" to the objects belonging to other clusters.

The objective of clustering is to determine the intrinsic grouping in a set of unlabeled data. It can be shown that there is no supreme "best" criterion which would be independent of the final objective of the clustering. Consequently, it is the user which must provide this criterion, in such a way that the result of the clustering will suit their needs.

3.2 Optimization

An optimization problem is the problem of finding the best solution from all possible solutions. Optimization problems can be divided into two categories depending on whether the variables are continuous or discrete. Classification of optimization algorithm can be carried out in many ways. A straightforward way is to look at the nature of the algorithm, and this divides the algorithm into two categories: deterministic algorithms, and stochastic algorithms.

Deterministic algorithms pursue a rigorous process, and its path and values of both design variables and the function are repeatable. On the other hand, stochastic algorithms always have some randomness and every individual path towards a possible solution is not exactly repeatable.

Several techniques are suitable only for specific types of problems. Thus, it is significant to identify the characteristics of a problem and to identify a suitable technique in the context of given problem to find the optimal solution, such that for each class of problems there are different minimization methods, varying in computational requirements, convergence properties, and so on. Optimization problems are classified according to the mathematical characteristics of the objective function, the constraints and the control variables. The most significant characteristic is the nature of the objective function. The relationship between the control variables is of a particular form, such as linear, e.g.

$f(x) = b^t x + c$ ……………………………(1)

Where b is a constant-valued vector and c is a constant, or quadratic, e.g.

$f(x) = x^t A x \; b^t x + c$ …………………………...…(2)

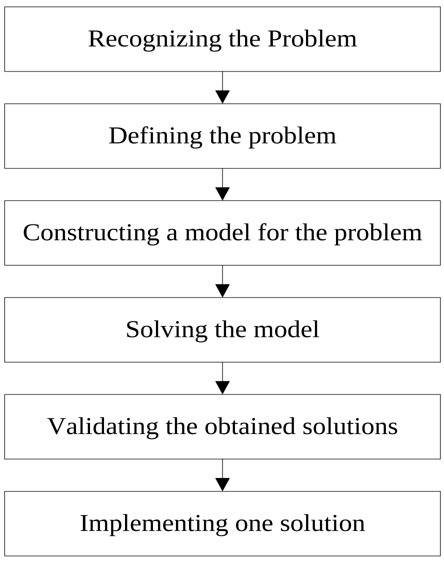

Fig. 1 Flow chart of Optimization Technique formulation

Where A is a constant-valued matrix, special methods exist that are guaranteed to locate the optimal solution very efficiently.

The optimization technique formulates the problem in given below steps:

1. Make a basic configuration

2. Recognize the decision variables

3. Establish the objective function

4. Recognize any constraints

5. Choose and apply an optimization method

IV. SWARM INTELLIGENCE BASED OPTIMIZATION TECHNIQUES

The different SI based optimization techniques are given as:-

4.1 Ant Colony

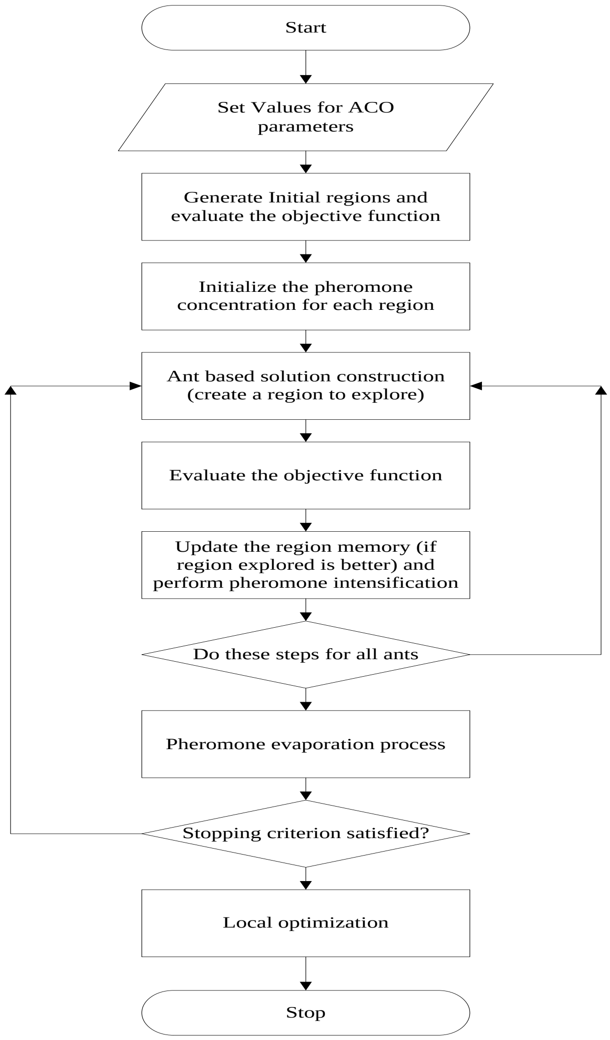

Fig. 2 Flow chart of Ant Colony Optimization Algorithm

ACO is among the most successful swarm based algorithms propounded by Dorigo & Di Caro in 1999 [12] .It is a meta heuristic inspired by the foraging actions of ants in the wild, and moreover, the phenomena known as stigmergy, term used by Grasse in 1959.Stigmergy refers to the indirect communication amongst a self-organizing emergent system via individuals modifying their local environment. The most interesting aspect of the collaborative behavior of several ant species is their ability to find shortest paths between the ants' nest and the food sources by tracing pheromone trails Then, ants choose the path to follow by a probabilistic decision biased by the amount of pheromone: the stronger the pheromone trail, the higher its desirability. Because ants in turn deposit pheromone on the path they are following, this behavior results in a self-reinforcing process leading to the formation of paths marked by high pheromone concentration. By modeling and simulating ant foraging behavior, brood sorting, nest building and self-assembling, etc. algorithms can be developed that could be used for complex, combinatorial optimization problems.

The first ant algorithm, named Ant System (AS), was developed in the nineties by Dorigo et al. (1996) and tested successfully on the well known benchmark Travelling Salesman Problem. The ACO meta heuristic was developed (Dorigo & Di Caro, 1999;) to generalize, the overall method of solving combinatorial problems by approximate solutions based on the generic behavior of natural ants. ACO is structured into three main functions as Ant Solutions Construct, Pheromone Update, and Deamon Actions.

4.2 Artificial bee colony

Artificial bee colony (ABC) Algorithm is an optimization algorithm based on the intelligent behavior of honey bee foraging. This model was introduced by Dervis Karaboga in 2005, and is based on inspecting the behaviors of real bees on finding nectar amounts and sharing the information of food sources to the other bees in the hive. These specialized bees try to maximize the nectar amount stored in the hive by performing efficient division of labour and self-organization [7]. The three agents in Artificial Bee Colony are: The Employed Bee, The Onlooker Bee , The Scout. The employed bees are associated with the specific food sources, onlooker bees watching the dance of employed bees within the hive to choose a food source, and scout bees searching for food sources randomly [4]. The onlooker bees and the scout bees are the unemployed bees. Initially, the scout bees discover the positions of all food sources, thereafter, the job of the employed bee starts. An artificial employed bee probabilistically obtains some modifications on the position in its memory to target a new food source and find the nectar amount or the fitness value of the new source. Later, the onlooker bee evaluates the information taken from all artificial employed bees and then chooses a final food source with the highest probability related to its nectar number. If the fitness value of new one is higher than that of the previous one, the bee forgets the old one and memorizes the new position [5]. This is called as greedy selection. Then the employed bee whose food source has been exhausted becomes a scout bee to search for the further food sources once again.

In ABC, the solutions represent the food sources and the nectar quantity of the food sources corresponds to the fitness of the associated solution. The number of the employed and the onlooker bees is same, and this number is equal to the number of food sources [8]. Employed bees whose solutions cannot be improved through a predetermined number of trials, specified by the user of the ABC algorithm and called ―limit‖, become scouts and their solutions are abandoned [4], [6].

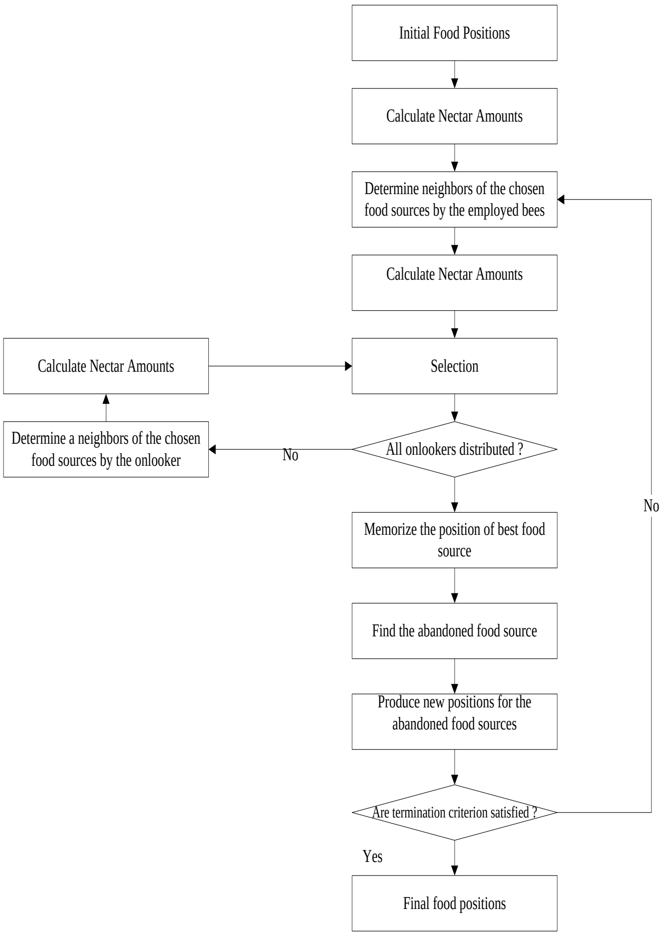

Fig. 3 Flow chart of Artificial Bee Colony Optimization Algorithm

4.3 Bacterial foraging

BFA is a newly introduced evolutionary optimization algorithm that mimics the foraging behavior of Escherichia coli (commonly referred to as E. coli) bacteria. [19] There are successful applications of BFA in optimization problems such as economic load dispatch and power systems. BFA models the movement of E. coli bacteria that thrive to find nutrient-rich locations in human intestine. An E. coli bacterium moves using a pattern of two types of movements: tumbling and swimming. Tumbling refers to a random change in the direction of movement, and swimming refers to moving in a straight line in a given direction. A bacterium in a neutral medium alternates between tumbling and swimming movements [19].

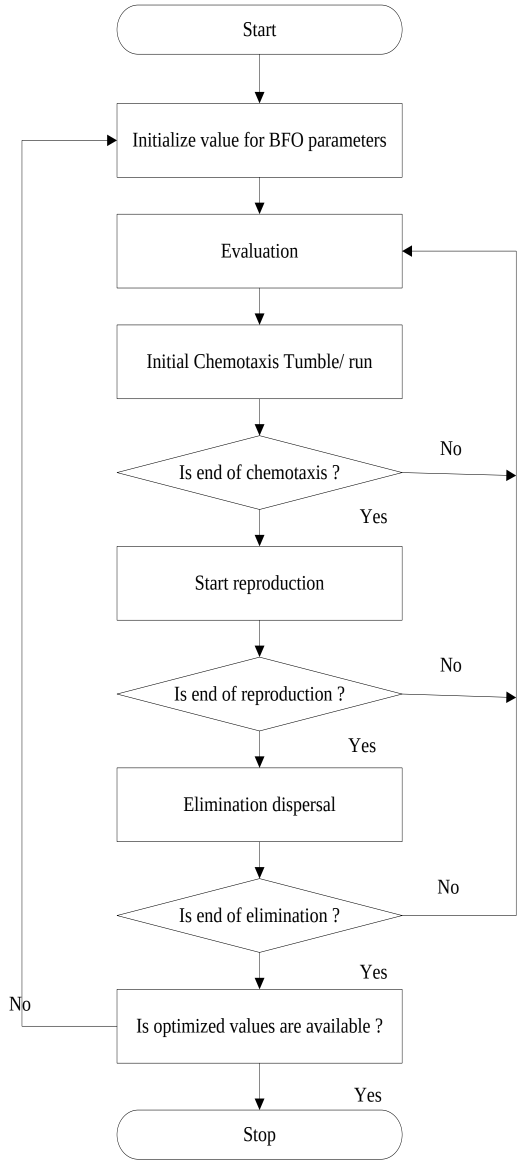

Fig. 4 Flow chart of Bacterial Foraging Algorithm

4.4 Bat algorithm

Xin-She Yang (2010) [3] propose the Bat Algorithm (BA), BA is inspired by the research on the social behavior of bats. The BA is based on the echolocation behaviour of bats. Microbats use a type of sonar (echolocation) to detect prey, avoid obstacles, and locate their roosting crevices in the dark. These bats emit a very loud sound pulse and listen for the echo that bounces back from the surrounding objects. Their pulses vary in properties and can be correlated with their hunting strategies, depending on the species [3]. Based on the above description of bat process, Xin-She Yang proposes the Bat algorithm. The structure of the pseudo code of the Bat Algorithm is as follows [3]

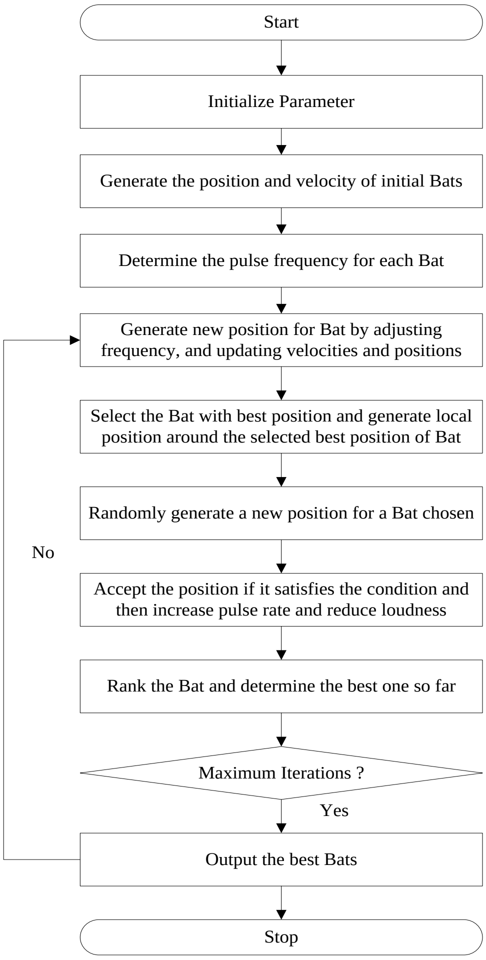

Fig. 5 Flow chart of Bat Algorithm

4.5 Cuckoo search

The CSA is introduced by yang and Deb in 2009 [11-12]. The CS was inspired by compel brood parasitism of cuckoo species by laying their eggs in the nests of host birds. Some cuckoos have evolved in such a way that female scrounging cuckoos can reproduce or rather imitate the colors and patterns of the eggs of a few chosen host species. This reduces the probability of the eggs being abandoned. Yang and dev also suggested in their research that levy flights is useful for improve solution quality besides on random walk method. A Levy flight is a random walk in which the step-lengths are distributed according to a heavy-tailed probability distribution. Each egg in a nest represents a solution .the objective it to employ good quality solution in the nest and replace those which are not so good solution. The algorithm based on three idealized rule:

- Each Cuckoo laid one egg only, and dumps the egg in a randomly chosen nest.
- The best nest (with quality solutions) will carry over the next generation.
- The number of available nest is fixed and a host can identify an alien egg with probability Pa [0, 1].

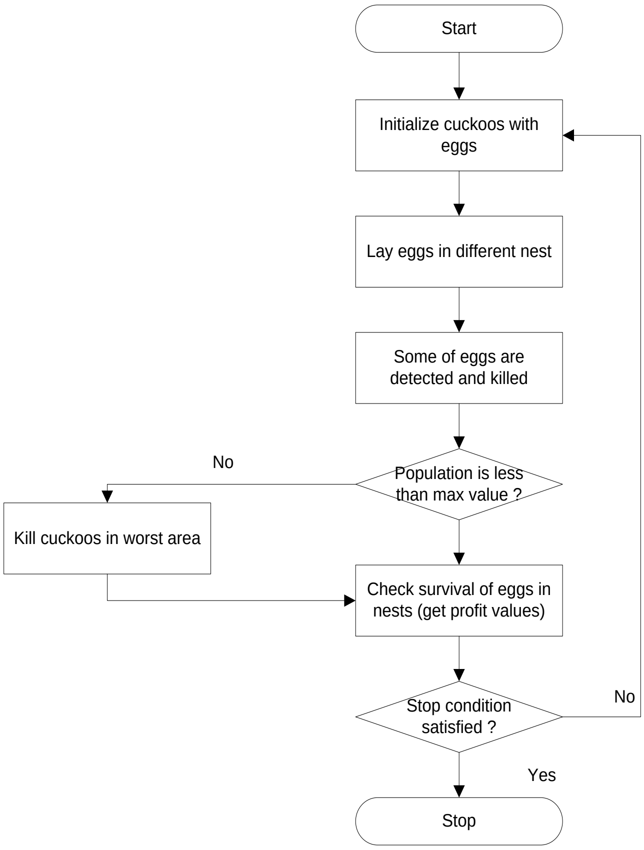

Fig. 6 Flow chart of Cuckoo Search Algorithm

4.6 Firefly

Fire flies, also called glowworms or lightning bugs are found all over the world. There are around two thousand firefly species and most fireflies produce short and rhythmic flashes of light. The pattern of flashes is often unique for a particular species. The fundamental functions of such flashes are to attract mating partners and preys. Females respond to male's unique pattern of flashing within the same species. The light emitting from their body strictly obeys the inverse square law i.e. as the distance between two flies increases, the intensity of light decreases. The air absorbs light, which becomes weaker and weaker as the distance increases. The bioluminescence from the body of the fireflies is due to 'luciferin', which is a heterocyclic compound.

Xin-She Yang [2] put forward firefly algorithm with inspiration from collective social behavior of fireflies promoted by communication through bioluminescence of characteristic different glittering patterns of flashes. It is another population based metaheuristic algorithm and used in nonlinear multimodal optimization in dynamic environment. The algorithm is formulated by assuming (i) All fireflies are unisexual, so that one firefly will be attracted to all other fireflies. (ii) Attractiveness is proportional to their brightness, and for any two fireflies, the less bright one will be attracted by (and thus move to) the brighter one; however, the brightness can decreases as the distance between them increases. (iii) If there are no fireflies brighter than a given firefly, it will move randomly. The brightness is associated with the objective function and the associated constraints along with the local activities carried out by the fireflies.[13]

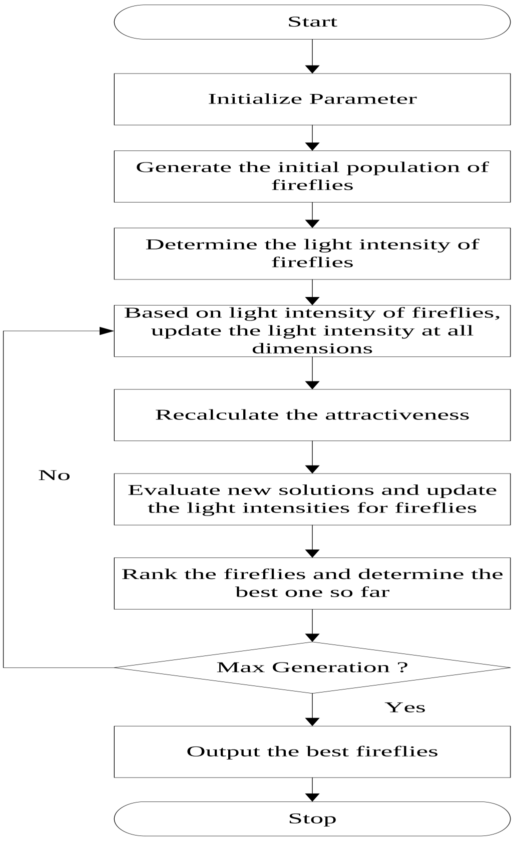

Fig. 7 Flow chart of Firefly Algorithm

4.7 Krill herd

Many Research have been done in order to find the mechanism that lead to the development non- random formation of groups by various marine animals [14,15].The significant mechanisms identified are feeding ability, protection from predators, enhanced reproduction and environmental condition.

Krills from Antarctic region are one of the best researched marine animals. One of the most significant ability of krills is that they can form large swarms [16, 17].Yet there are number of uncertainties about the mechanism that lead to distribution of krill herd [18].There are proposed conceptual models to explain observed formation of krill heard [19] and result obtained from those models states that krill swarms form the basic unit of organization for this species.

Whenever predators (Penguins, Sea Birds) attack krill swarms, they take individual krill which leads in reducing the krill density. After the attack by predators, formation of krill is a multi- objective process mainly including two Goals: (1) Increasing Krill density and (2) Reaching food. Attraction of Krill to increase density and finding food are used as objective function which finally lead the krills to herd around global minima. In this mechanism, all individual krill moves towards the best possible solution while searching for highest density and food.

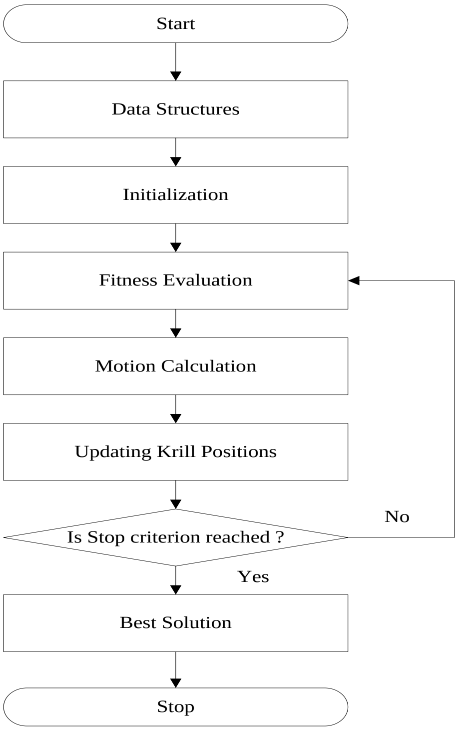

Fig. 8 Flow chart of Firefly Algorithm

Table I. A list of swarm intelligence algorithms

S.No.	Algorithm	Principle	Propounded By
1	**Ant Colony**	works on foraging behaviour of the ant for the food	Dorigo
2	**Artificial Bee Colony**	works on foraging behaviour of a honey bee	Karaboga and Basturk
3	**Bacterial Foraging**	works on behaviour of bacteria	Passino
4	**Bat Algorithm**	works on echolocation behaviour of microbats	Yang
5	**Cuckoo Search**	works on breeding behaviour of a cuckoos	Yang and Deb
6	**Firefly Algorithm**	works on lighting behaviour of firefly	Yang
7	**Krill Herd**	works on herding behaviour of krill individual	Gandomi and Alavi

V. CONCLUSION

Nature inspired algorithms are going to be a new revolution in the field of computer science, transportation engineering, mechanical engineering, management and so on. The scope of this area is really vast since as compared to nature, computer science problems are only a subset, opening a new era in next generation computing, modelling and algorithm engineering. This paper provides an overview of a range of nature inspired swarm Intelligence based optimization techniques. Generally speaking, almost all of the SI algorithms perform with heuristic population-based search procedures that incorporate random variation and selection. It has been witnessed that the applications and growth of natural computing in the last years is very drastic and has been applied to numerous optimization problems in computer networks, control systems, bioinformatics, data mining, game theory, music, biometrics, power systems, image processing, industry and engineering, parallel and distributed computing, robotics, economics and finance, forecasting problems, applications involving the security of information systems etc. Nature inspired computing still has much room to grow since this research community is quite young. There still remain significantly challenging tasks for the research community to address for the realization of many existing and most of the emerging areas in technology.

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