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Study Of The Swarm Intelligence Algorithms

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Abstract

Nature had given the best solutions of any real world problems. From the past few decades researchers & scientiests are trying to obtained nature inspired computational methods such as swarm intelligence, evolutionary algorithm, genetic algorithm etc. which can help to solve the complex problems. In this paper, we propose a swarm intelligence algorithms inspired by biology behaviors known as biomimetic optimization algorithms, such as Ant Colon Optimization (ACO) proposed by Mark Dorigo in 1992, Particle Swam Optimization introduced by James Kennedy and Russ Eberhart in 1995 & Bacterial Foraging Optimization (BFO) proposed by K. M. Passino in 2002, to tackle complex search problems of the real world. This paper present a comprehensive study of several nature inspired algorithms and their applications, advantages & limitations.

Keyword:- swarm Intelligence, Evolutionary Algorithm, Genetic Algorithm, Ant Colony Optimization, Particle Swarm Optimization, Bacterial Foraging Optimization

I. Introduction

Nature is the best example to figure out the problems of real world in a reliable manner. From the last few decades scientists & researchers are attempt to create computational methods that can solve complex problem. There are several nature inspired optimization algorithms are introduced such as Evolutionary Algorithm (EA) [1], Genetic Algorithm (GA) [2], Evolutionary Programming (EP) [3], and Evolutionary Strategies (ES) [4]. Evolutionary Algorithm is based on the biological behavior first applied by Charles Darwin. The Darwinian Theory based on the adaptive change of social insects using the method of natural selection, which approve those insects for survival. The evolutionary algorithm proposed by Holland and these algorithm consist genetic algorithm, evolutionary programming & evolutionary strategies.

The Genetic algorithm is proved by J.H. Holland in 1970's. In the genetic algorithm mechanism the powerful & healthy individuals are succeed in a competing environment. These solve the problem in the form of number of string & always apply recombination operator with the selection & mutation. The basic steps of genetic algorithm are as follow, create population as string, evolution (evaluate the all strings), selection (select the best string) & genetic manipulation (create new population of string with the mutation and reproduction).

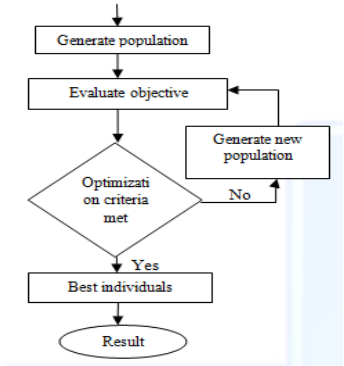

Fig. 1 Structure of Evolutionary Algorithm

Recently natural Swarm Intelligence [5] based optimization algorithms such as Ant Colony Optimization (ACO) [6], Particle Swarm Optimization (PSO) [7], and Bacterial Foraging Optimization (BFO) [8] are appreciated by biological behavior so also known as bio-mimic optimization algorithms .

In the past, people observed the various spices & insects behavior like ants group forge for food, bird flock sweep across sky etc. these kind of motion is known as swarm behavior. This is inspired by social foraging behavior. Foraging can be described as an optimization process where animal search for food in a way that maximizes their energy per unit time spent in foraging. So the Swarm intelligence is the biological inspired field based on collective behavior of insects like ant, birds, and various bacteria's. These show the self initiated and indirect communication between insect. The swarm intelligence behavior is also known as emergent behavior. In this paper we introduce several swarm intelligence algorithms ACO, PSO and BFO.

II. Ant Colony Optimization (ACO)

Ant Colony Optimization is an optimization technology to find optimizes solution of a problem. This optimization algorithm is first introduced by Mark Dorigo [9] in 1992. Ant Colony Optimization is inspired by food search ability (foraging) behavior of ant spices. The ants drop pheromone (scent or chemical produced by ants) on the floor in order to characterize some specific path that is followed by the other ants of that Colony. The ants have way of finding the shortest path. Important aspect for the social life of various ant species is the trail pheromone. Trail pheromone is a type of pheromone that is used by some ant species for marking the path which is used for forge the food. By sense the pheromone other ant species follow the path to the food discovered by an ant. The pheromone trail-laying-following behaviors of ant species are investigated by several researchers

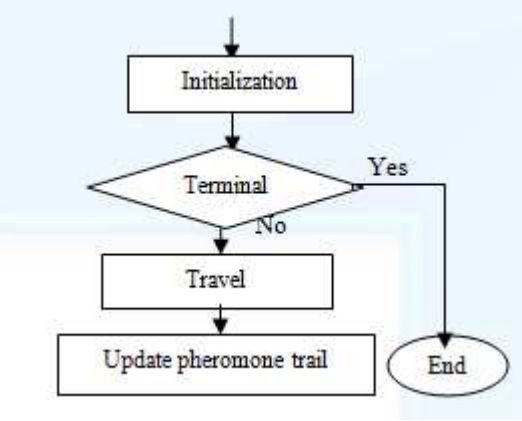

Fig. 2 Ant Colony Optimization Algorithm flowchart

For the initialization some initialization are necessary that are, instance must be read, distance must be computed, the nearest neighbors of all path has to be computed, the pheromone matrix must be initialize, the ants must be initialized and the parameter must be initialize. The program end if one termination condition is applies. The termination conditions are, found a solution within a predefined path distance; maximum number of iteration has been reached and the algorithm show inactive behavior. after that the travel require some phases that are ant memory has to be empty, each ant must be assign an initial city, an construct a simple tour and finally each ant back to initial stop (city) & after that distance of each path is computed. The last and final stage is the pheromone trail update. Pheromone update can be global & local update. These compromise two procedure that are pheromone evaporation (decrease the value of trail by a constant factor), and pheromone deposit (add pheromone with the arcs that are construct by ant).

There are several application of Ant Colony Optimization which are used in real world that are traffic system, routing problems, traveling salesmen problem, assignment problem, set problem etc. these are also applicable to those problem whose computational architecture is distributed.

The Ant Colony Optimization Algorithm is used because of positive feedback for discovery of best solution, efficient for traveling problems and adaptation of change so used for dynamic application. But it also has some limitations that are, its theoretical analysis is difficult, dependent on Sequences of random decisions (not independent), convergence time is uncertain and experimental research then theoretical.

III. Particle Swarm Optimization (PSO) Algorithm

Particle Swarm Optimization is a stochastic biological inspired optimization algorithm introduces by James Kennedy and Russ Eberhart in 1995 based on social behavior of bird flocking & fish schooling. Particle Swarm Optimization uses a several numbers of particles that compose a swarm moving in the search space to find the best solution. The PSO algorithm emulates from animals societies behavior which haven't any leader in their group and follow one of the member in the group who have closet position from the food. This is the potential solution of the problem. The flock finds their best position through communication from the members of the group who already have better position. Swarm which has better position will inform to its flock and all other flocks move simultaneously to that food place. This process repeat until best position discovered.

The Particle Swarm Optimization algorithm first select particle that are uniformly distributed after that evaluate each particle position according to the optimized objective function & determine fitness. If Current particle position is best then previous best one updates its position. Now update particle velocity and move particle to their next new position. If the criteria is satisfies then stop otherwise evaluate fitness of each particle.

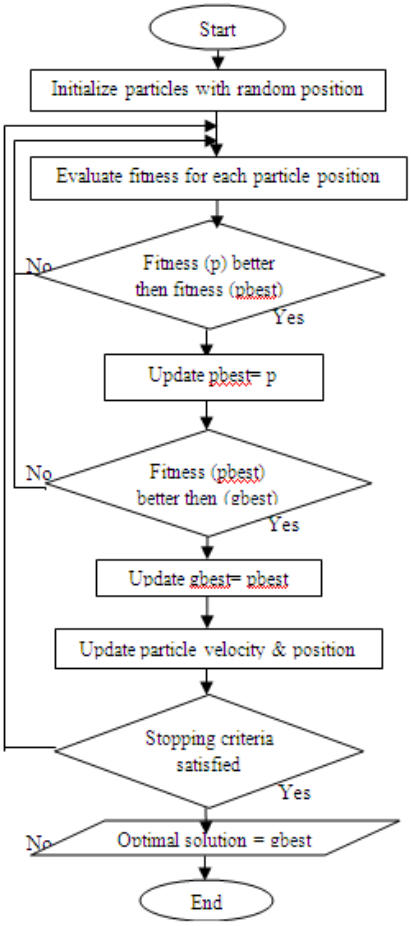

Fig. 3 Particle Swarm Optimization Algorithm flowchart

There are several application areas of PSO algorithm that are control, data mining, telecommunication, power system etc. PSO algorithm is generally used to solve single & multi objective optimization problems. PSO algorithm is based on swarm intelligence so it can be used as scientific research as well as engineering problems. This algorithm is simple then other intelligence algorithms and has no overlapping & mutation calculation. With these advantages PSO also have some limitations such as easily suffer from partial optimize so distract from there position & speed. This is not suitable for scattering & non coordinate system problems.

IV. Bacterial Foraging Optimization (BFO) Algorithm

Bacterial Foraging Optimization (BFO) is a nature inspired global optimization algorithm which is based on the social foraging behavior of E. coli (Escherichia Coli) bacteria and proposed by K.M. Passino in 2002. The Bacterial Foraging Optimization is based on bacterial foraging behavior by swimming & tumbling so this firstly used for control & optimization problems. The basic idea behind the BFO is the group foraging strategy of swarm of E. coli bacteria where the foraging strategy includes the method of searching, handling & investigating the food.

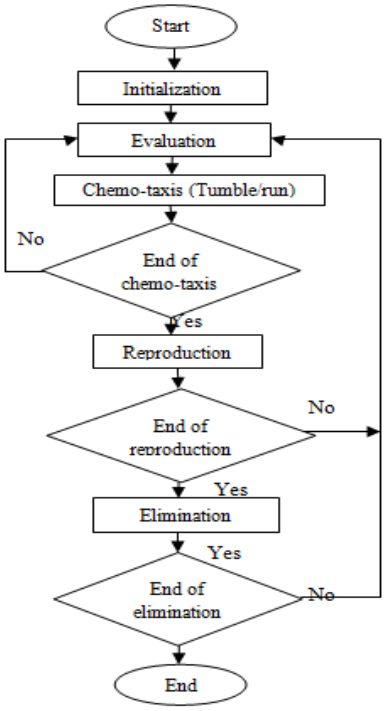

Fig. 4 Bacterial Foraging Optimization algorithm flowchart

The natural selection eliminates the animals that have poor foraging strategy and favor to those animal that have good foraging strategies. After that poor foraging strategy are eliminated & disperse in new once. So basically in BFO the E. coli bacteria have four stage that are chemo-tactic, swarming, reproduction, elimination & dispersal.

The chemo-tactic process achieved by the movement of the E. coli through the swim & tumbles via flagella according to some chemical the environment. If flagella rotate counter clock wise it called swim and if rotate clockwise called tumble. Swarming behavior observed in many bacterial species when a group of bacteria (E. coli) is placed in center of a semisolid agar with a single nutrient chemo-effecter or a sensor then they move out from the center in a traveling ring of cells by moving up the nutrient gradient that is created by the group.

For the reproduction the poor healthy bacteria dies and healthier bacteria is split into two bacteria at the same place to keep the population constant in appropriate condition.

In the environment Elimination & dispersal event can occurs because bacteria population change due to some influence so some bacteria are dies and others are disperse in new part of that environment. The BFO algorithm can

be used for several applications such as control system, optimization problems, signal processing system etc. Bacterial Foraging Optimization attract to the scientist & researchers due to its simplicity and good efficiency to solving optimization problems.

V. Conclusion

Nature inspired algorithm already achieved success in engineering problems. This paper present the theroritical fundamentals of the bio-mimic optimization algorithms which help in the studying the way in which industrial machine can work and many types of control problems can solve in easy way. These algorithms can be analysed for future enhancment by improving performance and reducing the limitations.

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