specifically collective behavior of decentralized, self-organized systems interacting with their environment and each other which is known as swarm intelligence. Swarm intelligence is the discipline that deals with natural and artificial systems consist of many individuals that coordinate using decentralized control and self-organization. More specifically, the discipline focuses on the collective behaviors which result from the local interactions of the individuals with each other and with their environment. Examples of systems studied by swarm intelligence are colonies of ants, schools of fish, flocks of birds, herds of land animals. Some human artifacts are also included into this domain. Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) are the most popular examples of swarm intelligence. ACO is inspired by behavior of ants while PSO is based on behavior of bird swarm.

2.2 Introduction

The process of improving something than its current condition is called as optimization. It is the process of adjusting inputs, mathematical process or device characteristics to get the required output. This process is called as fitness function, objective function or cost function. Different methods are used for finding optimal solution while some of them are inspired by natural behaviour of some living elements like bees, birds, ants etc [5].

Particle Swarm Optimization is inspired by behaviour of bird flocking. This algorithm consists of swarm of particles i.e. group of random particles where each single solution is a bird (particle) in the search space. Optimized solution for every particle is determined by fitness function. Group of birds search for food by observing fitness function [10]. By following leader particle which is nearest to the food they can find the food. Leader particle is nothing but current optimal solution. So, every problem is initialized with random particles. PSO is based on birds swarm searching for optimal food sources in which direction of birds movement is influenced by its current movement, the best food source experienced by it ever and best food source any bird in the swarm ever experienced i.e. known as personal best and global best values and they get updated new best values after each iteration in PSO [5]. The personal best value is represented as u_p and global best value is represented as u_g. Particles movement is decided by following iteration in PSO:

$$u^{(i)}(n+1) = u^{(i)}(n) + v^{(i)}(n+1) \qquad (1.a)$$

$n = 0, 1,2, ..., N-1,$

Where $u^{(i)}$ is the position of particle i, $v^{(i)}$ is the velocity of particle i, n is iteration, n= 0 indicates initialization and N is total number of iterations [2].

The velocity of the particle is given as

$$v^{(i)}(n+1)=v^{(i)}(n)+2r_1^{(i)}(n)[u_p^{(i)}(n)-u^{(i)}(n)] + 2r_2^{(i)}(n)[u_g(n) - u^{(i)}(n)], \qquad (1.b)$$

Where u_p is the personal best position, u_g is the personal best position. $u_p^{(i)}(n)-u^{(i)}(n)$ calculates vector in the direction of personal best position and $u_g(n) - u^{(i)}(n)$ gives vector directed towards global best position. $r_1^{(i)}$ and $r_2^{(i)}$ both represent random vectors which has values uniformly distributed between 0 and 1.

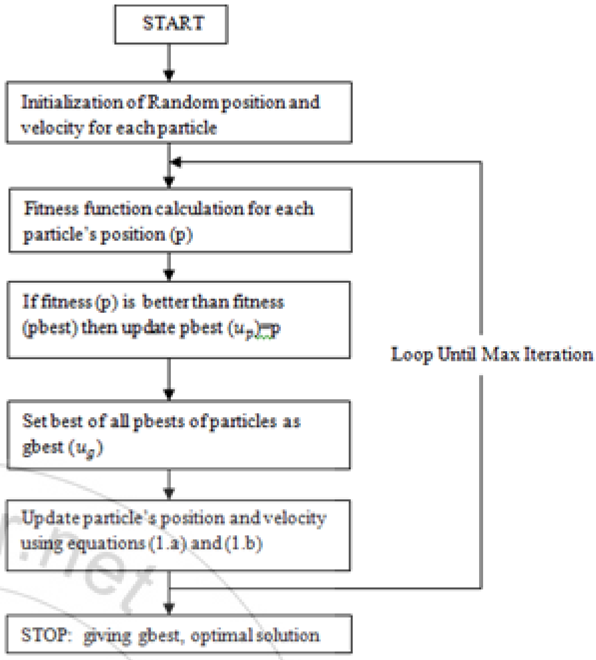

Figure 1: Flowchart of PSO Algorithm

As shown in flowchart in fig. (1), firstly initialization of swarm i.e. the position and velocity of particles are randomly initialized within the search space. After that, fitness function or objective values of particles are calculated. These first objective values and positions are automatically considered as personal best values and personal best positions. The best fitness value among all particles that particle's position and fitness value is considered as global best position and value in the entire swarm. By using equation (1.a) and (1.b) the position and velocity of particles are updated. In next iteration, again fitness value is calculated at updated position of each particle. Next step is to compare that personal best fitness with old personal best fitness value. If new fitness value is better than old one, we update personal best fitness value. Best of personal best value among all particles in whole swarm is set as global best fitness value. Then update particle's position and velocity according to above equations. This process continues with evaluating personal best positions and fitness values also global best position and value. This algorithm stops running when termination criterion meets i.e. either satisfactory optimal solution has been achieved or number of iterations is reached. Iteration stopping criteria can also be termination when no improvement is observed over a number of iteration.

2.3 The PSO Algorithm

As already discussed before, PSO is the simulation of the behaviors of bird flocking in which group of birds searches for food randomly in particular area. Initially they don't know the location of piece of food but after each iteration they will find out how far the food is available. They just follow the bird which is nearest to the food.

approach has robust, high convergence rate, precision and it can give satisfactory solutions of nonlinear equations.

Similarly combination of different bioinspired optimization techniques can be used to provide better results. For global optimization of multimodal functions hybrid version of Genetic Algorithm (GA) and Particle Swarm Optimization which is known as GA-PSO algorithm. Though PSO has many advantages over GA, main problem of PSO is premature convergence [3]. Hybrid version of PSO and GA is used to overcome limitations of PSO. This hybrid algorithm has three approaches. In first one approach global best particle position does not change its position for some steps. The crossover operation is performed on global best particle with chromosomes of GA. PSO and GA both run in parallel in this type. In second type mutation operator of GA is used to change positions of the stagnated personal best particles. In the third model of this hybrid version total number of iterations are divided equally among GA and PSO. First half of total iterations is used by GA and solution of GA is assigned as initial population to PSO algorithm. Similarly, Ant Colony Optimization and PSO combination is used as another hybrid PSO known as ACO/PSO technique used to optimize multicast tree. In this algorithm large number of mobile agents generated initially, their movement is guided by pheromones as in ACO and global maximum of attribute values are obtained through the random interaction between agents using PSO algorithm [9].

5. Conclusion

In the past several years, Particle Swarm Optimization (PSO) has been successfully applied in many research and application areas such as fuzzy system control, function optimization, artificial neural network training, wireless sensor network etc. It is proved that PSO gets better results in faster, cheaper way as compared to other optimization method. PSO is very popular optimization technique because it has very few parameters to adjust. For wide variety of application, classical PSO can be modified to another version with slight variation in parameter.

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