Particle Swarm Optimization- A Review on Algorithmic Rule, Application and Scope

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Abstract: *Particle swarm optimization is a population-based, meta-heuristic optimization technique based on intelligence of swarm. The research on flock of birds or fish has been the motivation for this algorithm. Since this algorithm is easy to implement and requires few particles for tuning, this has been used widely nowadays. The main idea of this paper is to present the principle of PSO, improved PSO and research situation and the scope of future research.*

Keywords: Classification, Particle swarm optimization (PSO), Meta-heuristic, Swarm Intelligence, Population Based Algorithm (PBA)

1. Introduction

Classification can be either heuristic or meta-heuristic. Heuristic means 'to find' and meta-heuristic means 'to guide'. Meta-heuristic has the aim to explore the search space in order to find (near) optimal solutions. Meta-heuristic has the trajectory methods and population-based methods. Particle swarm optimization (PSO) is one of the population based algorithm. This method is forwarded originally by Dr.Kennedy and Eberhart in 1995. It is developed from swarm intelligence based on the research of flock of bird or fish. While the swarm or birds wander for food, they are either scattered or go together before they find place of food. When the birds move from one place to another for food, there is a bird which is intelligent about the resource information of the food. As they transmit messages (best) at any time during the search of food, the birds flock together to the place where the food is. Now when the algorithm is considered, the birds moving from one place to another is development of solution swarm, message is most optimist solution and the food resource is the most optimist solution in the whole. The most optimist solution can be used in particle swarm optimization by coordination of each individual. The particle without standard and volume serves as each individual and the behavioral pattern is applied for each particle to show the complexity of whole particle swarm. So this method can work out the complex optimist problems and can be used in wide area of fields like function optimization, model classification, neural network training etc.

2. Particle Swarm Optimization

Particle swarm optimization is one of the population based optimization technique. PSO is popular for its search speed and it is used to solve many complicated optimization and search problem. Many variants of the original PSO has been proposed. As the algorithm considers the pbest value, it is useful for small number of particles. If it considers the gbest value, it is useful for large number of particles.

Particle swarm optimization (PSO) provides good solution for optimization problems through intelligence generated from complex activities like cooperation and competition among individuals in the biologic colony. This method is a type of evolutionary computing based on swarm intelligence. The basic idea is that in a bird colony, each bird looks for its own food and in the mean time they cooperate with each other by sharing information among them. Therefore each bird will explore next promising area by its own experience and experience from others. Due to these attractive features, memory and cooperation, PSO is applied in many research area.

Here we present the basic particle swarm optimization algorithm. The particle swarm consists of particles "n" and the position of each one stands for the solution in the given dimensional space. the particles change its condition according to the following three principles
1) to keep its inertia
2) to modify the condition according to its most optimist position
3) to change the condition according to the swarm's most optimist position

The position of each particle in the swarm can be affected during its movement as well as its surroundings. Each particle has its current speed and position, the most optimist position of each particle and the most optimist position of the surrounding. The speed and position of each particle can change according to the following equation:

$$V_i^{k+1} = V_i^k + C_1 r_i^k (pbest_i^k - X_i^k) + C_2 r_2^k (gbest_i^k - X_i^k)$$
$$X_i^{k+1} = Xx_i^k + V_i^{k+1}$$

1) V and X represent the speed/velocity and position of particle 'i' at 'k' times.
2) pbest represents the best position of each particle at k times.
3) gbest represent the best position on the whole flock.

It is noted that three components contribute to the new velocity. The first part is proportional to the old velocity and is the tendency to move in the same direction it is travelling. The second one is associated with the local search i.e., individual thinking. The third term is concerned with the global search i.e., socio-psychological adaptation of knowledge.

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3. Analysis of pros and cons of Particle Swarm Optimization

The general characteristics of the population-based optimization are
i. trial and error search
ii. graduated solution quality
iii. stochastic search of solution landscape
iv. Population of candidate solutions.

Pros of Particle Swarm Optimization (PSO)
i. PSO is more general purpose than traditional Optimization algorithms.
ii. PSO has the ability to solve "difficult" problems.
iii. PSO has the availability of solution
iv. PSO is known for its Robustness and Inherent Parallelism

Cons of Particle Swarm Optimization (PSO)
i. PSO's fitness function and search techniques are often not obvious.
ii. PSO has the tendency of premature convergence.
iii. PSO is computationally intensive.
iv. PSO deals with difficult parameter optimization.

4. Review of Literature

The research status of Particle Swarm Optimization through survey is given below. J.Kennedy and R.Eberhart in 1995 [1] proposed PSO concept which reviews the stages of precursors development from social simulation to optimizer.. They also introduced [2] a new form of PSO which examines how the changes in the parameter affect the number of iterations required to meet an error criterion and the frequency with which models cycle around a nonglobal optimum. But there was a problem of "stagnation" and "exploitation".

Van den Bergh and A.P.Engelbrecht [3] solved this particular problem with Guaranteed Convergence PSO (GCPSO) by using a different velocity update equation for the best particle since its local best and global best lie at the same point, where traditional PSO inhibits the explorative ability of the best particle because it is strongly pulled toward that one point. GCPSO guarantees convergence towards a local minimum.

As there is again a problem, that is the particles converge towards local minima before encountering the global minimum. This again solved by Van den Bergh [4] by developing multi-start PSO which automatically triggers a restart when stagnation is encountered. Restart refers to new search in different sequence.

Many variants of original PSO has been proposed which increases the inertia weights, convergence factor, selection and blending of the PSO algorithm with other intelligent algorithms. Many authors has reviewed the PSO, its development, applications, resources [4] and also hybridization, combinatorial problems , multicriteria and constrained optimization [5][6], techniques, system and challenges [7], better generalization ability across the architecture space for computer-aided medical diagnosis[8], an ISO-FLANN for classification that explores the entire weight space [9] and with a boosting approach to extract rules for recognizing the presence or absence of coronary artery disease [10]

5. Future work

Future work in the field of PSO has to understand the area where it suffers and analyze any limitations and try to overcome those. Performance can be improvised by converging towards local minimum as in GCPSO. Other improvisations can be the use of inertia weights, increasing the convergence factor, selection mechanism and blending of PSO algorithm with other intelligent algorithms. Even though the PSO has shown to be effectively working there are lot of future work that can be done in terms of parameter, topology, and application area and blending with some other algorithms.

6. Conclusion

It has been proved from the study that Particle Swarm Optimization (PSO) is used in many real life problem domains. When compared with other algorithms this is easy and needs only less parameter. This can be utilized to solve optimization problems as well as the problems that can be solved into optimization problems. The concept of PSO has presented , modified and improved by many authors . One of the noted application approach is evolving Artificial Neural Network. When hybridizing these two there is a remarkable performance. And thus the future work of ours will be decision making in Heart Disease Prediction using PSO and Neural Network. This method will eventually cease the traditional Neural Network training algorithms because this is effective for any network architecture.

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