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Reviewing Particle Swarm Optimization (PSO) Algorithm's stimulations in WSN

Pinky Dagar

School Information Manager, GSSS Rohtak, Haryana

***Abstract*—Particle Swarm Optimization (PSO) is a member of the Swarm Intelligence family of population-based optimizers. The Particle Swarm Optimization (PSO) algorithm, as one of the latest algorithms inspired from the nature, was introduced in the mid-1990s. PSO gets better results in a faster, cheaper way compared with other methods. In this paper introduction of PSO algorithm is given, which is followed by the survey of major PSO based algorithms. The PSO have several advantages and applications which are given in this paper. Accordingly, various methods, advantages and application are discussed of the PSO algorithm.**

***Keywords*—ACO, PSO, Wireless Network, Optimization.**

I. INTRODUCTION

Conventional algorithms are not capable of solving real world problems due to incomplete and noisy data. Natural computing methods are useful for such problems. PSO Algorithm is of this type. PSO have the ability to be developed for various applications and does not need the previous knowledge of problem space. It is attractive to study because it has simple nature.PSO is a population-based optimization algorithm, inspired by the social behaviour of flocks of birds or fishes. Each particle is an individual and the swarm is composed of particles.The problem solution space is formulated as a search space. Each position in the search space is a correlated solution of the problem. In a PSO system, each particle is "flown" through the multidimensional search space, adjusting its position in search space according to its own experience and that of neighboring particles.

Suppose a group of birds are searching for food in a place randomly and food is available in one part of searching area and the birds have no information about the place where the food is available and they only know their distance to the food source. The adopted strategy by birds is that they follow the bird which has minimum distance to the food source. In PSO algorithm, each answer to the problem is considered as a bird in the search space which is called a particle. Each particle has its own fitness determined by the fitness function. A bird which is close to food source has a better fitness.

The features of the method are as follows:

(1) The method is based on researches on swarms such as fish schooling and bird flocking.

(2) It is based on a simple concept. Therefore, the computation time is short and it requires few memories.

II. PSO DESCRIPTION

PSO is developed through simulation of bird flocking in two-dimension space. The position of each individual particle is represented by XY axis position and also the velocity is expressed by VX (the velocity of X axis) and Vy(the velocity of Y axis). Modification of the agent position is realized by the position and velocity information. Each particle knows its best value so far (pbest) and its XY position. Moreover, each agent knows the best value so far in the group (gbest) among pbest. Each particle tries to modify its position using the following information:

a) The current positions (x, y)

b) The current velocities (Vx,Vy)

c) The distance between the current position, and pbest and gbest.

This modification can be represented by the concept of velocity. Velocity of each agent can be modified by the following equation: This modification can be represented by the concept of velocity. Velocity of each agent can be modified by the following equation:

$$\boldsymbol{v_i(t+1) = w * V_i(t) + c_1 * rand() * (p_i best\ x_i(t)) + c_2 * rand() * ((g_i best - X_i(t))}$$

……. (1)

The current position (searching point in the solution space) can be modified by the following equation:

$$\boldsymbol{x_i(t+1) = x_i(t) + v_i(t+1)}$$

…….. (2)

Where, v (t) Velocity of agent, c1 & c2 are weighting factor or learning coefficients. Usually c1 is equal to c2, and they are in the range (1,2).w is weighting function or inertia factor, usually is a number in the range(0,1) , rand( ) is random function in the range of (0,1), x(t) is current position of particle , pbest is best of particle and gbest is best of the group. Also the final value for velocity of each particle is limited to a span to avoid the divergence of each algorithm: vi Є [-vmax ,vmax].Typically, this process is iterated for a certain number of time steps, or until some acceptable solution has been found by the algorithm.

III. OTHER OPTIMIZATION ALGORITHMS

The other heuristic algorithms are genetic algorithm (GA), differential evolution (DE) and bacterial foraging algorithm (BFA). GA facilitates evolution of the population generation by generation using operators such as crossover, mutation and selection.

DE is similar to GA, but it uses a differential operator, which creates a new solution vector by mutating an existing one by a difference randomly chosen vectors.

BFA models the foraging behavior of bacteria that use a combination of straight line and random movements to reach nutrient rich locations

IV. MAJOR PSO BASED ALGORITHM

Active Target PSO (APSO) – In this algorithm, in addition to two existing terms the best position and the best previous position, a third term called 'Active target' is also utilized. Calculating the third term is complicated. The third term does not belong to the existing positions. This method maintains the diversity of the PSO as well as not trapping in the local optimum [4].

Adaptive PSO (APSO) – During the running process of the PSO, sometimes a number of particles are inactive, that is, they do not have the ability of local and global searching and do not change their positions, so their velocity is nearly reached to zero. One solution to this is to adaptively replace the current inactive particles with fresh particles in a way that the existing PSO-based relationships among the particles are kept. This solution is given by APSO method [5].

Adaptive Mutation PSO (AMPSO) –This algorithm utilizes the adaptive mutation using Beta distribution in the PSO. It has two types: AMPSO1 and AMPSO2. The AMPSO1 mutes the best individual position in the swarm and the AMPSO2 mutes the best global position in the swarm [6].

Adaptive PSO Guided by Acceleration Information (AGPSO) – This algorithm is for improving the PSO efficiency in finding the global optimum. The acceleration item is also added to position and velocity updating equations and then convergence analysis is performed [7].

Best Rotation PSO (BRPSO) – This algorithm is used to optimize multimodal functions. The swarm is divided into several sub-swarms. However in normal PSO in multimodal functions the wide knowledge of the whole population performance make the system converges too fast and also increases the probability of stagnation into local minima but in BRPSO when best rotation is executed, stagnation on local minima is avoided by forcing populations to move from one local minimum to another one, increasing the exploration of the problem space between different local minima. Therefore in this algorithm periodically rotation is performed among the particles of different sub-swarms [8].

Binary PSO (BPSO) – The difference between PSO and BPSO lies in their searching spaces. In the PSO, moving in the space means a change in the value of position coordinates in one or more of existing dimensions. However, in the BPSO moving in the spaces means a change in the probability of the fact that the value of position coordinate is zero or one [9].

Combinatorial PSO (CPSO) – This algorithm is employed to optimize hybrid problems (consist of continuous and integer variables) [12].

Constrained optimization via PSO (COPSO) – This algorithm is applied to constrained single-objective problems. A technique is employed to investigate the constraints and it has an external file which is called as "Tolerant", Tolerant is used to save the particles. In order to develop the lifetime of these particles, the above-mentioned external file is utilized and a ring topology structure is employed. In fact, the COPSO is a kind of improvement in Lbest version of the PSO.

Cooperatively Coevolving Particle Swarms (CCPSO) – This algorithm is suitable for large-scale problems. It breaks the problem into some smaller-scaled ones so that the internal dependencies of generated particles are in the possible least values. Then, these particles will become cooperated [14]

Cooperative Multiple PSO (CMPSO) -The CMPSO algorithm is introduced to overcome the problem in PSO (Efficiency of PSO is reduced when solving multi-dimensional problems).This algorithm has all conductivity and control properties of the PSO [13].

Dissipative PSO (DPSO) – Sometimes in PSO, swarm's have the tendency to get the equilibrium status. Thus, the algorithm will be prevented from searching for more areas and it may be trapped in a local minimum. Therefore in order to overcome this problem, a dissipative system is made using the DPSO algorithm introducing the negative entropy and producing craziness among particles [90].

Dynamic adaptive dissipative PSO (ADPSO) – A dissipative is made for the PSO introducing negative entropy and a mutation operator is utilized to increase the variety in the swarm when it reaches an equilibrium condition in last runs. Therefore, it generates an adaptive strategy for inertia weight in order to keep the balance between the local and global optimality [16].

Dynamic Double Particle Swarm Optimizer (DDPSO) –This algorithm, guarantees the convergence to the global optimal solution. Particle position constraints are set dynamically in this method [17].

Estimation of Distribution PSO (EDPSO) – This algorithm is a hybrid of the PSO and Estimation of Distribution Algorithm (EDA). The ED algorithms are used to find better areas using the obtained information from stochastic models. This feature of such an algorithm is utilized to improve the performance of PSO [18].

Evolutionary Programming and PSO (EPPSO) – This algorithm is a combination of the PSO and EP. The combination of these two algorithms will help the PSO capability in making a balance between local and global search to the faster convergence of the EP algorithm. The PSO's drawback in lacking diversity among the particles with mutation between elements in the EP is to some extent removed [19].

Fully-informed PSO (FIPS)-In this algorithm, all particles have an information source and there is no difference in the amount of their information [20].

Fuzzy PSO (FPSO) – In the FPSO algorithm, the idea of PSO is used together with an explicit selection procedure.

Self-adapting characteristics are utilized to set the parameters. Generally the replication, mutation, reproduction evaluation and selection operations are employed in this operations are employed in this algorithm.

Geometric PSO (GPSO) – In this algorithm there is a use of a geometric framework for connection between the PSO and evolutionary algorithms. The generated algorithm will be applied to both continuous and combinational spaces and it will cover most of the problems [21].

Genetic PSO (GPSO) – GPSO was derived from the original PSO. It was incorporated with the genetic reproduction mechanisms, namely called as crossover and mutation [22].

Genetic binary PSO model (GBPSO) – GBPSO was developed to increase the dynamic conditions and discovery power in the swarm. In the BPSO, bear and death parameters are employed. According to BPSO principles, the positions and velocities are updated and then, some of the child particles are added to swarm and some others die and are separated from the swarm. In binary state each particle is considered as a chromosome and chain with the size of space dimension [23].

Heuristic PSO (HPSO) - A variant of particle swarm optimizer called HPSO was introduced in 2007. It differed from the original PSO in choosing the next particle to update its velocity and position. This approach can speed up the convergence rate of the swarm to a local optimum. Particle's positions are re-initialized randomly when their position is close to the global best position in order to remove premature convergence. This helps HPSO to outperform the basic PSO and some variations of PSO in some test cases [24].

Hierarchical PSO (HPSO) – The particles are arranged in a dynamic hierarchy used to define a neighborhood structure. The particles move up or down depending on the quality of their so-far best-found [34].

Improved Particle swarm optimizer (IPSO) – It is based on PSOPC. Moreover, it uses a harmony search. It utilizes a mechanism called as fly-back in order to employ the constraints [25].

Iteration PSO (IPSO) – In IPSO, to improve solution quality and computation efficiency, a new index called iteration best is incorporated into the PSO. Different cost factors such as expanding line construction cost, contract recovery cost, demand contract capacity cost, and penalty bill etc. are considered in selecting the optimal contract capacities.

Modified Binary PSO (MBPSO) – This algorithm is a modified version of the BPSO algorithm. All the particles are produced as binary vectors and in a random way. To map the binary space to the permutation space the least value of position is used. New equations are employed to update the position and velocity in the algorithm [27].

Modified Genetic PSO (MGPSO) –This algorithm is the combination of the two algorithms known as GPSO and DE (differential Evolution). In this algorithm, the main focus is to improve the GPSO performance. For each particle updating of the next position is done by both algorithms and the better result will be the benchmark for the next movement of the particle [28].

Neural PSO (NPSO) – A feed forward neural network is combined with the PSO in this method. Neural particles are defined in space like feed forward neural network. The learning process is the movement of particles following the bests in space [29].

NewPSO (NPSO) – The worst are used to calculate the Pbest and Gbest instead of bests. These are utilized with negative sign in velocity updating equation. Using this process, it is tried to get farther from the worst instead of getting closer to the best [30].

Optimized PSO (OPSO) – In this there are swarms within a swarm to optimize the free parameters of the PSO. Test results bring to view the better performance of this method compared to other methods [31].

Parallel PSO (PPSO) – Time requirements for solving complex large-scale engineering problems can be substantially reduced using parallel computation in this algorithm.

Parallel Asynchronous PSO (PAPSO) – This algorithm was extracted from the PSPSO algorithm. Particles and velocity updating is done continuously based on existing information. To reduce the imbalance load, it generates a dynamic view of load balancing along with a chain-duty central approach.The difference between being synchronous and asynchronous lies in the position and velocity updating equations.

Parallel synchronous PSO (PSPSO) – This algorithm performs the position and velocity updating at the end of each iteration. It uses a constant load balancing [33].

PSO with behavior of distance (BDPSO) – In this algorithm, the flying area of particle is divided into various areas. The swarm will not have a constant behavior. In attraction area particles fly faster towards the best position and in repulsive area they move at a normal rate .This different behavior depends on the area in which particles are flying [34].

Restricted Velocity PSO (RVPSO) – There are sometimes problems in which the search space has an acceptable range. To solve such problems, the RVPSO approach is applied. In this approach, the particle velocity is constricted considering the constraint. However, the PSO algorithm is for unconstrained optimization problem in which the search space is infinite. [48].

Self-organization PSO (SOPSO) –In addition to particle information and total swarm information, a feedback agent is employed to improve the particle performance. This helps to improves particle behavior in next iteration. Generally, this agent will lead in improvements in discovery. The main objective of this algorithm is to avoid premature convergence of the total algorithm [33].

Two-Swarm-based PSO (TSPSO) - To escape from being trapped in local optimum and to avoid quick convergence, TSPSO algorithm is used. Two swarms with different parameters are flown is the space where the particles of both swarms have different paths. One of them will enhance the capability of finding the global optimum and the other will enhance the local discovery using the Roulette-wheel-selection based stochastic selection scheme [35].

Unconstrained PSO (UPSO) – The PSO is divided to constrained and unconstrained categories depending on the velocity or position parameter. The position and velocity updating equations are the same in both states. However, in the constrained, there are up and down constraints for position and velocity, if they are exceeded, these constraints will be considered. But in UPSO such a constraint does not exist [36].

Velocity Limited PSO (VLPSO) –Different optimal solutions are used if particles moving velocity is limited in various ranges. Thus, considering and regarding up and down constraints the VLPSO approach is proposed [37]. The particles satisfying the constraints will be kept and the others are eliminated in this algorithm.

V. ADVANTAGES OF PSO

- Ease of implementation on hardware or software.
- Availability of guidelines for choosing its parameters.

- High quality solutions because of its ability to escape from local optima.
- Availability of variants for real, integer and binary domains.
- A derivative-free technique.
- Generate high-quality solutions with shorter calculation time and stable convergence characteristic

Particle swarm optimization technique has been used for approaches that can be used across a wide range of applications ranging from biological and medical applications to computer graphics and music composition. It is also used for specific applications focused on a specific requirement. The PSO based algorithms are used for various applications ranging:-

- In sensor network the tasks of pso are: - - Optimal WSN deployment - Stationary node and Mobile node positioning.
- Energy – Aware Clustering (EAC) in WSN.
- Node Localization in WSN -Determinations of locations of target node.
- Data Aggregation in WSN – Optimal Allocation Power Allocation, Determination of Optimal – Local Thresholds, Optimal Sensor Configuration [45].
- Civil Engineering, Chemical process, Traffic Management.
- Biological and Medical applications.
- Filter design, Fault Detection and recovery, Image and sound analysis, Design and control of fuzzy systems, Control applications, Design and control of neural networks.
- Dynamics System, Robotics.Biological and Medical applications.
- Optimization of constrained problems to Combinational optimization.
- Security and Military applications.
- Computer graphics and Composition of Music.
- Multi objective optimization.

VI. CONCLUSION

In past several years, PSO has been successfully applied in many research and application areas. It is demonstrated that PSO gets better results in a faster, cheaper way compared with other methods. In this paper, general view of PSO algorithm and various major PSO-based algorithms ramified from this algorithm as well as from its various applications are present. The methods branched from this algorithm and their applications have developed a lot.

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