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A Review: Comparative Study of Various Particle Swarm Optimization Methods in Computational Intelligences

M.Lavanya
Assistant Professor, Department of Computer Science and Engineering,
Bharathiyar Institute of Engineering for Women,
Deviyakurichi Post, Attur Taluk, Salem Dt, India.
praiselavan@gmail.com

Abstract

Computational intelligence is a set of nature-inspired computational methodologies and approaches to address complex real-world problem to which mathematical or traditional modelling can be useless to solve. Because, the processes might be complex for mathematical reasoning and many real life problems cannot be translated into binary language for computers to process. This situation arise the need of evolutionary algorithm in computational intelligence to provide the solutions for such problems. Particle swarm optimization is one of the evolutionary algorithm. Particle swarm optimization method optimizes a problem by iteratively trying to improve a candidate solution with the measure of quality. PSO optimizes a problem by introducing various types of PSO algorithms. This paper reviews different types of particle swarm optimization methods used to solve- the discrete optimization problems, continuous optimization problem and about hybrid PSO.

Keyword

Computational Intelligence, Particle Swarm Optimization, Genetic Algorithm, Discrete and Continuous Optimization problem.

Introduction

Particle Swarm Optimization (PSO) is a population based stochastic optimization technique developed by Kennedy, Eberhart and Shi[1] in 1995, inspired by social behavior of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithm (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. The advantages of PSO are that PSO is easy to implement and there are few parameters to adjust PSO has been successfully applied in many areas like function optimization, artificial neural network training, fuzzy system control, and other areas.

PSO based Algorithm for Discrete Optimization Problems

The original PSO was designed for continuous search space but latter many problems are having a finite number of elements in their domain. To solve this

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problem, Kennedy and Eberhart introduced a binary edition of PSO for discrete optimization problems. Here, every particle takes its position in binary values which are 'zero' or 'one'. Particle's velocity will be determined by the probability of changing its bit status from 0 to 1. The proposed BPSO algorithm [2] has modified the logic of calculating the particle's velocity.

In order to solve the job shop scheduling (JSP), a few modifications are done on BPSO to schedule m jobs in n resources. In this paper, Improved BPSO [3] has proposed with Sig function modification and with some new constraints. In the proposed PPSO algorithm in [4], the fitness evaluation for all the variables or elements in the domain should be done before updating particles velocity and position, during each iteration. As the name implies, the fitness assessment of all variables in the domain should done in parallel.

From the paper [5] has proposed a new PSO called EDPSO. The local best particle and global best particle has been found through much iteration. After that, the velocity for each particle is calculated using a modified velocity updating equation.

PSO based Algorithm for Continuous Optimization Problems

The combination of cellular automata (CA) and particle swarm optimization (PSO) yields a novel idea called CPSO which proposed by [6]. Two version of CPSO are designed, namely, CPSO-inner and CPSO-outer. CPSO-inner algorithm updates particles by using the information inside the swarm. The performance of CPSO-inner algorithm greatly depends on the dimensionality of the problems. CPSO-outer algorithm utilizes the information from outside the swarm during the updating process which means 'smart cells'. In CPSO-outer, particles inside the swarm (smart-cells) communicate with cells outside the swarm during the updating process. By using this information, particles will move wisely over the search space and avoid the trapping of local optimum.

ELPSO algorithm is proposed in order to keep a balance between swarm diversity and convergence speed. To update the position of the particle, ELPSO uses an example set of multiple global best particles not by using single-global best particle. pPSA algorithm has been presented to overcome the drawback of PSO as, the lost of diversity and premature convergence or global best corresponds to local optima through creating perturbation on the global particles. This can be done by changing the velocity and position updating equations.

Hybrid PSO

The proposed hybrid PSO proposed in [7] has combine the adaptive PSO (APSO) with a new PSO called diversity guided PSO based on gradient search (DGPSOGS). First, the adaptive PSO is used to search the solution until the swarm loses its diversity. Suppose, if the swarm loses its diversity, DGPSOGS algorithm is used to search the optimal solution which can retain the diversity. Based on the threshold value of diversity, the search will be performed either by APSO or DGPSOGS algorithm. The proposed hybrid approach is based on the hybridization of PSO and genetic algorithm (GA). Additionally, the

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local search (LS) scheme is implemented to improve the solution quality of optimization problems. This algorithm is employed for multi-objective optimization problems.

The MCPSO algorithm has been proposed to improve the performance of standard particle swarm optimization (SPSO). MCPSO is a master- slave form which has several slave swarms and one master swarm. Slave swarms are to maintain the convergence speed. Master swarm will progress based on its own awareness and also an information from the slave swarms. Master swarm takes care of retaining the diversity over the search space which is one of the drawbacks of traditional PSO.

Occasionally, the assessment process in PSO will be idle due to an equilibrium state of a swarm. To avoid this scenario, [8] has constructed the dissipative system using DPSO by introducing negative entropy which generates confusion among particles. By using this system, the above mentioned problem will be prevented. Since the PSO hasn't able to accomplish the good performance on different fitness backgrounds, SLPSO algorithm has been proposed. SLPSO is used to improve the robustness of PSO on many practical problems where the fitness backgrounds are typically unknown.

The CPSO algorithm has proposed to enhance the concert of the conventional PSO algorithm. Instead of holding one swarm for the whole search space to find the optimal solution, the search space is split into many components of forming n-swarms. Using multiple swarms, CPSO considerately optimize the diverse components of many solutions. This will improve the performance of the conventional PSO algorithm. A Novel algorithm HPSO proposed which hybridizes PSO and henon map mutation strategy to enhance the particles exploration ability and convergence speed. The new PSO algorithm performs better when it is tested with other hybrid PSO algorithm using a benchmark function.

Conclusion

Discrete optimization problem or combinatorial optimization problem means searching for an optimal solution in a finite or countably infinite set of potential solutions. Optimally is defined with respect to some criterion function, which is to be minimized or maximized. In continuous optimization, the variables in the model are normally allowed to take on a continuous range of values, usually real numbers. This feature distinguish continuous optimization from discrete or combinatorial optimization, in which the variables may be binary restricted to the values 0 and 1. Continuous optimization problems are typically solved using algorithms that generate a sequence of values of the variables, known as iterates, that converge to a solution of the problem. The basic drawbacks of PSO is that the swarm may prematurely converge and problem-dependent performance. To overcome the limitations of PSO, hybrid PSO has proposed to solve various problems.

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