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Survey Paper on A Hybrid Approach using Particle Swarm Optimization with Linear Crossover to Solve Continuous Optimization Problem

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Abstract—

This paper presents a Hybrid version of Particle Swarm Optimization to solve Continuous Optimization problem with Linear Crossover. Here a modified approach to PSO has been approached. In order to show the performance of hybrid algorithm, this paper focus on the behavior of proposed algorithm a modified approach to PSO with crossover operator. A linear crossover operator is used in this experiment. Various benchmark functions have also been used to prove the efficiency of these functions.

Keywords: Particle Swarm Optimization (PSO), Particle Swarm Optimization with Crossover (PSO with Crossover), Linear Crossover.

I. INTRODUCTION

Particle swarm optimization (PSO) is a population based heuristic search technique developed by Dr.Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. The PSO algorithm finds the global best solution by simply adjusting the trajectory of each individual toward its own best location and toward the best particle of the entire swarm at each time step (generation). The PSO method is becoming very popular due to its simplicity of implementation and ability to quickly converge to a reasonably good solution. Since the PSO algorithm is easy to implement and efficient when solving many optimization problems, it has attracted much attention. Many researchers have worked on improving its performance in different ways, thereby developing many interesting versions of PSO. The PSO method is becoming very popular due to its simplicity of implementation and ability to quickly converge to a reasonably good solution.

However, it was pointed out that PSO usually suffers from premature convergence, tending to get stuck in local optima, low solution precision and so on. In order to overcome these shortcomings and get better results, numerous improvements to PSO have been proposed, which probably can be separated into two types. The first type, such as inertia weight, fuzzy inertia weight, and adaptive inertia weight and so on, is to change the inertia weight *w* to make the algorithm has strong global searching ability in the beginning and also strong local searching ability in the end. The second type tries to change the structure of the algorithm or associate with other optimization algorithms (e.g. genetic algorithm) such as constriction factor, parallelizing PSO and so on. Then, those improved PSO always have better performance than the basic algorithm. On the basis of those improvements, a novel version of PSO with crossover operator is proposed in this paper by adding a crossover step to the standard PSO. After the crossover, the fitness of the individual best position is compared with two offspring produced after crossing. And then we choose better one as the new individual best position. Through the crossover operator, PSO can make use of the others' advantage to avoid being trapped into local optima. Five benchmark functions are tested, and the result indicates that the modified particle swarm optimization is effective.

In this paper a new method proposed using PSO with linear crossover operator to solve the continuous optimization problem. Using the features of PSO and real coded linear crossover operator of genetic algorithm, new method proposed and it gives optimal result. In continuous optimization, the variables in the model are nominally allowed to take on a continuous range of values, usually real numbers. This feature distinguishes continuous optimization from discrete or combinatorial optimization, in which the variables may be binary (restricted to the values 0 and 1), integer (for which only integer values are allowed), or more abstract objects drawn from sets with finitely many elements.

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. In deciding how to step from one iterate to the next, the algorithm makes use of knowledge gained at previous iterates, and information about the model at the current iterate, possibly including information about its sensitivity to perturbations in the variables. The continuous nature of the problem allows sensitivities to be defined in terms of first and second derivatives of the functions that define the models.

II. LITERATURE REVIEW

Many Researchers have proposed various methodologies for finding a best solution. Ahmed A.A.Esmin et al [1] in A Hybrid Particle Swarm Optimization Algorithm with Genetic Mutation proposed a hybrid particle swarm optimization algorithm that uses the mutation process to improve the standard particle swarm optimization (PSO) algorithm. Mutation operators are an integral part of evolutionary computation techniques, preventing loss of diversity in a population of solutions, which allows a greater region of the search space to be covered. The main idea of the HPSOM is to integrate the PSO with genetic algorithm mutation method. Jiahua Xie and Jie Yang [2] proposed a novel crossover operator for Particle swarm algorithm to enhance the performance of PSO. This proposed approach is called LPSO employs a Laplace Crossover operator (LC) to generate good candidate solutions. Laplace crossover operator is used to generate new offsprings and compete it with its parent. After that the fitter particle is updated as the new current particle. Millie Pant et all [3] in Particle swarm optimization with crossover operator and its engineering applications proposed an algorithm named Quadratic Interpolation Particle Swarm Optimization (QIPSO) for solving global optimization problems. In this scheme the conventional framework of PSO is modified by including a crossover operator to maintain the level of diversity in the swarm population. Loss of diversity generally takes place when the balance between two antagonists processes exploration (searching of the search space) and exploitation (convergence towards the optimum) is disturbed. To overcome this problem the above algorithm is proposed in this paper. Jong-Bae Park et all [4] presented an efficient approach for solving the economic dispatch (ED) problems with valve-point effects using a hybrid particle swarm optimization (PSO) technique. This paper proposed a hybrid PSO (HPSO), which combines the conventional PSO technique with the crossover operation. The crossover operation, which was widely used in the genetic algorithm (GA) methods to increase the exploration and exploitation capability of the PSO mechanism. The main objective of ED problem is to minimize the total fuel cost of power plants subjected to the operating constraints of a power system. Payam Chiniforooshan and Shahrooz Shahparvari [5] proposed a hybrid algorithm that combines differential evolution with particle swarm optimization, namely HDEPSO. The main objective of this paper is to achieve faster convergence rate and obtain better pareto optimal solutions. Zhi-Feng Hao et all [6] in A particle swarm optimization algorithm with crossover operator, developed a method in which a crossover step is added to the standard PSO. The crossover is taken between each particle's individual best positions. After the crossover, the fitness of the individual best position is compared with that of the two offsprings and the best one is taken as the new individual best position. In this paper the experimental result indicates that the modified algorithm increases the ability to break away from the local optimum. Anjali Thareja and Dr. Archna Kumar [7] proposed a modified approach to PSO with crossover operator. In this paper, uniform crossover operator is taken as crossover method. Real coded uniform crossover generates two offsprings from a pair of parents by uniformly replacing their elements on each locus at certain probability.

III. PARTICLE SWARM OPTIMIZATION

As PSO is inspired from bird flocking it uses velocity equation to update the solutions and fly towards the best solution. This process continues, iteratively, until either the desired result is converged upon, or it's determined that an acceptable solution cannot be found within computational limits.

First the initial population is selected randomly from the solution search space than the position of particles are updated until the maximum limit of iteration or desired feasible solution found. For an n-dimensional search space, the i^{th} particle of the swarm is represented by an n-dimensional vector, Xi = (xi1 ,xi2 .....xin)T . The velocity of this particle is represented by another n-dimensional vector Vi = (vi1; vi2...... vin)T. The previously best visited position of the ith particle is denoted as Pi = (pi1, pi2,........pin).`g' is the index of the best particle in the swarm. The velocity of the ith particle is updated using the velocity update equation given by

$V_{id} = v_{id} + c1r1(p_{id} - x_{id}) + c2r2(p_{gd} - x_{id})$ (1)

and the position is updated using $x_{id} = x_{id} + v_{id}$ (2)

where d = 1, 2....n ; i = 1; 2....S , where S is the size of the swarm; c1 and c2 are constants, called cognitive and social scaling parameters respectively (usually, c1 = c2 ; r1 , r2 are random numbers, uniformly distributed in [0, 1]). Equations (1) and (2) are the initial version of PSO algorithm. A constant, V_{max}, is used to arbitrarily limit the velocities of the particles and improve the resolution of the search. Further, the concept of an inertia weight was developed to better control exploration and exploitation. The motivation was to be able to eliminate the need for V_{max}. The inclusion of an inertia weight (w) in the particle swarm optimization algorithm was first reported in the literature in 1998 (Shi and Eberhart,1998). The resulting velocity update equation becomes:

$v_{id} = w * v_{id} + c1\ r1(p_{id} - x_{id}) + c2\ r2(p_{gd} - x_{id})$ (3)

IV. PSO WITH CROSSOVER OPERATOR

PSO algorithms have been successful in solving a wide variety of problems, their performance is criticized one certain aspects. Particle swarm optimization (PSO) is a population based heuristic search technique used for optimization problems. PSO is an effective optimization technique for continuous optimization problem. Crossover operator is a main operator of genetic algorithm. Crossover operators use the property of two solutions and generate new solutions. It may be possible that the generated child or solution is better than the parent. Crossover operator is of two types one is binary crossover operator and other one is real coded crossover operator. Linear crossover operator is real coded crossover operator used to solve real coded optimization problem. In these paper features of PSO is merged with linear crossover operator to solve continuous optimization problems.

V. LINEAR CROSSOVER OPERATOR

Linear crossover is one of the earliest operator in real coded crossover it generates three solutions from two parents and the best two offsprings replace parents.

Let ($x_1^{(1,t)}$ $x_2^{(1,t)}$ $x_3^{(1,t)}$ $x_4^{(1,t)}$ …........... $x_n^{(1,t)}$) and ($x_1^{(2,t)}$ $x_2^{(2,t)}$ $x_3^{(2,t)}$ $x_4^{(2,t)}$ …........... $x_n^{(2,t)}$) are two parent solutions of dimension n at generation t. Linear crossover generates three offsprings from these parents as shown in equation (4),(5) and (6) and best two offsprings being chosen as offsprings.

$0.5(x_i^{(1, t)} + x_i^{(2, t)})$ (4)

$(1.5x_i^{(1, t)} - 0.5x_i^{(2, t)})$ (5)

$(-0.5x_i^{(1, t)} + 1.5x_i^{(2, t)})$ (6)

i = 1, 2,…………………………., n

VI. PSO WITH LINEAR CROSSOVER OPERATOR

In this paper PSO with linear crossover operator applied to the continuous optimization problem for testing efficiency of algorithm. Two Particles generated by PSO are randomly selected for crossover operation and two new offsprings are formed. The best offspring (in terms of fitness) is selected from the new offspring. This new best offspring replaces the worst parent particle which is selected for crossover. The replacement is done if the new best offspring has the good fitness value than the parent particle.

VII. CONCLUSION

PSO is a population-based evolutionary computation technique. In order to improve these shortcomings of PSO: premature convergence, tending to get stuck in local optima and low solution precision when solving high-dimension functions, a novel version of particle swarm optimization algorithm with crossover operator is proposed in this paper. The experimental result indicates that the modified algorithm increases the ability to break away from the local optimum.

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