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Particle Swarm Optimization Using Blended Crossover Operator

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Abstract: In recent days, Swarm Intelligence plays an important role in solving many real life optimization problems. Particle Swarm Optimization (PSO) is swarm intelligence based search and optimization algorithm which is used to solve global optimization problems. But due to lack of population diversity and premature convergence it is often trapped into local optima. We can increase diversity and prevent premature convergence by using some evolutionary operators in PSO. In this paper the blend crossover operator is used to increase the search ability of the swarm in the search space .Particle Swarm Optimization uses this crossover technique to converge optimum solution fast .Thus the blend crossover operator is combined with particle swarm optimization to enhance the performance and keep the diversity which guides the particles to the global optimum efficiently. In this paper a blended crossover based particle swarm optimization algorithm (BCPSO) has been proposed and the proposed algorithm has been tested with some standard benchmark functions. Result shows the promising performance of the algorithm.

Keywords: Particle Swarm Optimization, Swarm Intelligence, Blend Crossover Operator.

INTRODUCTION

Till date there are various nature inspired algorithms [1] have been developed. Ant Colony Optimization (ACO) [3], Genetic Algorithm (GA) [4] , Artificial Bee Colony (ABC) [5] are few names of this category. ACO is based on the behavior of ants in which ants are follow the shortest path from their colony to the source of food , ABC is proposed by karaboga for optimizing numerical problems and GA is a evolutionary algorithm which is used to generate optimized solution using various techniques selection , mutation and crossover. These algorithms are often used to solve various optimization problems [2] that arise in the field of science and technology .The basic nature of these algorithms is that all the algorithms are population based and stochastic. But among all the algorithms Particle Swarm Optimization (PSO) [6] has been used successfully in solving many optimization problems, for its simplicity and fast convergence rate.

Although there are lot of population based search algorithms, but we cannot say that which algorithm is better because one algorithm may better for some problems and may be worse for others. On the basis of our requirement we choose the algorithm and optimize the problem. Similar case is possible for PSO, sometimes PSO may not provide the optimal solution for some complex problems, but after some modification we can get the optimal solution.

Those algorithms which are based on the swarm are comes under the swarm intelligence. Swarm intelligence is the branch of artificial intelligence and based on collective behavior of self organized system [7]. Particle Swarm Optimization is also a swarm intelligence algorithm, because in this algorithm a group of population or swarm is used to explore the search space to get the optimal point. The optimize value of the function using Particle Swarm Optimization Algorithm is depends on the exploration and exploitation of the particles during searching in the search space[9] .There are a major problem in PSO is that when it applies to various global optimization problems it may get stuck in the local optimization due to premature convergence because the diversity decreases with the time for a large population[10] , So we apply various evolutionary operator like crossover to get the global optimal solution[11][12][14].The blend crossover is a crossover operator which is applied in basic PSO to explore the search area . The blend crossover operator is a modified crossover operator, which is apply to the PSO to optimize the function .The search area of any function is the bounded region in which the function lies. Various algorithms are applied to the function's bounded region to get the optimal solution of the function. In this paper we used various benchmark functions to test the algorithm.

PARTICLE SWARM OPTIMIZATION (PSO)

Particle swarm optimization is developed by R.Eberhart and J.Kennedy in the year 1995.This algorithm is inspired by the flocking of birds and fish schooling. It is a population based approach searching in a search space to find out the optimal solution. The particles in this algorithm are represented by a D dimensional vector as X $[x_1,x_2,x_3\ldots\ldots,x_D]$ and the velocity vector $V[v_1,v_2,v_3,\ldots\ldots.v_D]$.Best particle of the entire swarm is known as global best (G_{best}) and for a particular particle it remembers its best position it has traversed so far is known as personal best (P_{best}). Particles in the search space update their position by using two equations. These equations are—

$$V_i^{t+1}=\omega*V_i^t+c_1*r_1*(P_{besti}-X_i) +c_2*r_2*(G_{best}-X_i) \quad (1)$$
$$X_i^{t+1}=X_i+V_i^{t+1} \quad (2)$$

These both equations are used to update the velocity and position of a particle in the search space .In these equations there are various constant values are used .The first part of the equation (1) contain the constant ω, which is known as inertia weight of the particle. It is used to balance the search abilities of the particle in the search space [12].In equation (1) the two constants c_1 and c_2 are known as acceleration coefficient and r_1 and r_2 are the uniformly distributed random number in between 0 and 1. The equation (2) uses the velocity obtained in first equation to get the new position of the particle.

Crossover

Crossover is a Genetic operator which is used after selection in Genetic Algorithm[4] to get the new children using two or more than two parent .It is used to get the better solution than existing solution. There are various modified version of crossover available to get the value of new species. Blend crossover [13] is also a modified operator which is used to get the new better child by using existing parent. This operator is applied in PSO to optimize the multi dimensional function and increase the searching ability of the PSO, So that Particle Swarm Optimization optimizes the functions efficiently and did not stuck in the local optima.

PROPOSED BCPSO ALGORITHM

Although the crossover operator is a concept of Genetic Algorithm but apart from genetic algorithm it can we use in many algorithms with some modifications .The crossover operator takes two or more than two parent and generate one or more than one child .The generated new child after crossover is better than their parents. There are various modified crossover technique, The blend crossover operator [13] is one of the modified crossover operator in which two particles are used to create a minimum and maximum range values which lies in the function's bounded region and the new particle is generated within the calculated minimum and maximum range values, Then we calculate the fitness value of that new particle and compare it with the existing particle and update the N_POP of the population of the particles.

Algorithm:-

PSO:
Begin
Initialize particle with Random Position and Velocity
Set $P\_best_i=X_i$,$g\_best=\min(P\_best_i)$
Initialize Generation as g=0;
While (g<max_generation)
For (i=1 to N_POP)
For (j=1 to D_POP)
Calculate V_i^{t+1}using equation (1);
Calculate X_i^{t+1} using equation (2)
If V_i^{t+1} and $X_i^{t+1}$are in search range then;
Evaluate fitness for corresponding particle x_i;
Apply blend crossover to calculate the new particle N_new
Calculate fitness value for new generated particle
Compare the fitness value for x_i and N_new;
If Fitness (N_new) is better than x_i then
Update the particle in N_POP
g=g+1;
End for
End for
End of while
Print the value of G_best.
End

BLEND CROSSOVER:
Begin
Select two random particles from N_POP x1 and x2
Calculate x_{new}=(x1-x2)
Calculate k_1=min(x1, x2)
Calculate k_2=max(x1, x2)
$k_{min}=k_1-a*x_{new}$;
$k_{max}=k_2+a*x_{new}$;
Where a is a random selected integer within range
Now select a random particle from the range
$N\_new=(k_{max}-k_{min})*rand+k_{min}$
Now calculate the fitness of new generated particle N_new
End

EXPERIMENTAL RESULTS AND DISCUSSIONS

Benchmark Functions

Benchmark functions are the standard functions which are used to test and compare various algorithms. In this paper we have taken various Benchmark Functions from theCEC-2005 [8] to compare the algorithms .These Benchmark functions are the combination of various different functions .The different algorithms are applied on these benchmark functions and calculate the optimize value of these functions.

Table1: Benchmark Functions of D dimension

Function	Function Name	Range
F1	Shifted Sphere Function	$[-100,100]^D$
F2	Shifted Schwefel Problem 1.2	$[-100,100]^D$
F3	Shifted Rotated High Conditioned Elliptic Function	$[-100,100]^D$
F4	Shifted Schwefel's Problem 1.2 with Noise in Fitness	$[-100,100]^D$
F5	Shifted Rosenbrock's Function	$[-100,100]^D$
F6	Shifted Rotated Griewank's Function without Bounds	$[0,600]^D$
F7	Shifted Rotated Ackley's Function with Global Optimum on Bounds	$[-32,32]^D$
F8	Shifted Expanded Griewank's plus Rosenbrock's Function	$[-3,1]^D$
F9	Shifted Rotated Expanded Scaffer's F6 Function	$[-100,100]^D$

Experimental Setup

All the algorithms used in this paper are executed in MATLAB 2010B using the following parameter settings:

Generation (G) = 6000
Population Size (NP) = 50
Dimensionality (D) = 30
C_1 = C_2 = 1.4916
Omega = 0.732.

30 independent test run has been considered for each algorithm to check the robustness of the algorithm. The output values of each function for various algorithms are shown in the tabular form in the Table 2.The various constants used in the algorithm are taken within the range .All the benchmark functions are minimized function in a given range and from the table we can see that the optimized value under the proposed algorithm BCPSO are better than the other algorithms. There may be some functions on which BCPSO is not better than other algorithms but also approached to the near optimal solution .So we can say that proposed algorithm is better than other algorithms.

Table 2: Comparison Result for dimension 30

Function	PSO	DVPSO	BCPSO
F1	3.952e+003	2.094e+004	**3.774e+003**
F2	**1.226e+004**	5.266e+004	1.470e+004
F3	1.880e+007	3.992e+008	**4.114e+006**
F4	**1.683e+004**	6.341e+004	2.946e+004
F5	4.498e+008	4.120e+009	**3.259e+008**
F6	4.700e+003	**1.205e+003**	3.636e+003
F7	1.191e+002	1.191e+002	**-1.191e+002**
F8	1.244e+002	2.058e+004	**-9.182e+001**
F9	2.878e+002	**2.863e+002**	2.874e+002

Results

The convergence graph created to test the convergence rate for various algorithms .The convergence graph for the various benchmark problems represents the fast convergence rate for BCPSO. .After each generation the rate of convergence for BCPSO is high then the PSO and DVPSO. And finally the BCPSO converges to the optimal point faster than other algorithm.

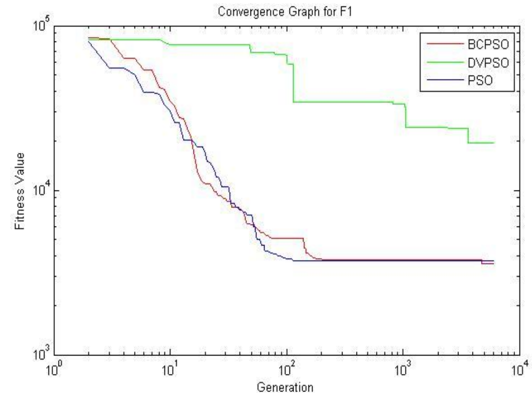

Fig 1: Convergence Graph for F1

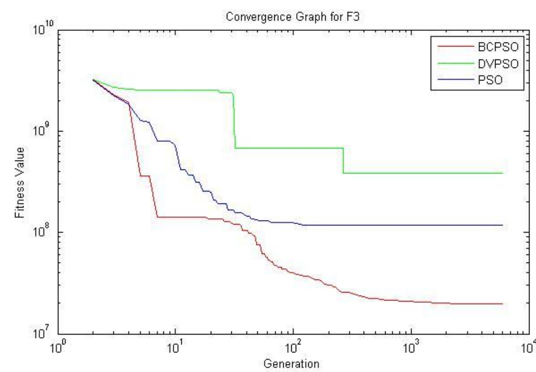

Fig 2: Convergence Graph for F3

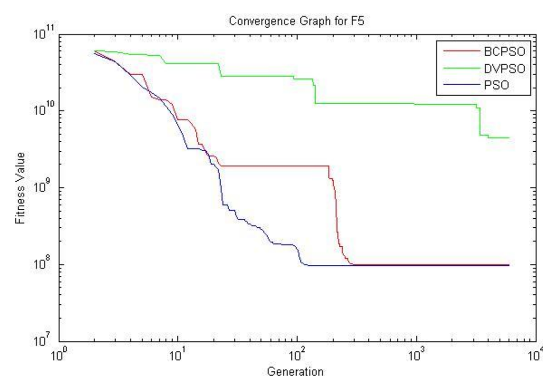

Fig 3: Convergence Graph for F5

CONCLUSION

The PSO with the crossover provides an optimal solution on different benchmark problems. The algorithm applied on 30 dimensions and calculates the solution, which compared with other algorithms and from the comparison we found that after the implementation of crossover operator we get the better solution. So if we can modify the basic PSO using crossover operator we can get better optimized value for multidimensional functions.

In this paper, we have applied blend crossover operator on PSO and get the optimum values of the standard benchmark functions, Similarly we can modified basic PSO by applying other existing techniques or by adding other constants in the original PSO and get the modified values .So if use modified PSO as compare to basic PSO in optimization problems then we can get better optimal values of various functions.

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