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New Particle Swarm Optimization with Diminishing Population

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Abstract

Particle Swarm Optimization (PSO) is a method of social investigation which its function is on this principle that in every moment, any particle regulates its position in searching space regarding to best resting position and best position in its neighbouring. Regarding to chronological process when the number of local minimum points as fitness function would be high, PSO algorithm in which will be easily captured by value of local optimum. Hence in this paper it is presented a method for implementation of PSO algorithm in which regarding to worst place of each particle and diminishing population by removing of low operation particles, by inhibition of capturing local optimum amounts and drives the particles toward the successful regions. The results show that implementation of this method for function with high local minimum would cause general searching, decreases the number of calculations and would result better optimum value than to PSO.

Keywords: Particle Swarm Optimization, local minimum, global search, Diminishing Population, Selection sort

1. INTRODUCTION

Particle Swarm Optimization (PSO) is a strong random optimizing technic based on movement and intelligence of groups which has been inspired from communal behavior of birds or fish groups. This algorithm applies concept of social mutual effect for solution of problem and first time introduced by James Kennedy and Russell Eberhart in 1995[1]. This technic is formed of some particles that are moving in searching space for finding best solution and has similarities with evolutional calculating technics such as Genetic algorithm. In PSO particles would flow in searching space and changing the place of particles in searching space affect by their knowledge and experience and their neighbours.

1.1. PSO Algorithm

PSO algorithm for solution of problem uses of some particles for searching in solution space (step1).in fact these particles would form PSO population. Each of particles have local position and velocity in searching space (step2) that would made randomly. Regarding to this, PSO is for optimizing the fitness function, the value of fitness for each particle is calculated by placement the position of that particle in fitness function (step3). Best position of particle is p_{best} .therefor p_{best} of each particle is equal to position in which particle has least fitness (step4). Best position in total neighbouring of particles is called g_{best} and is a position in which particle has least fitness between all of particles (step5). Searching of this algorithm is a repetitive process and when would reach to maximal repetition numbers that have been considered in initial of solving problem, will be stopped searching process (step6). In case that searching stop condition would not be settled, this algorithm must update position and velocity of particles in every repetition. Since in PSO in every step, any of particles regulates its position in searching space regarding to p_{best} and g_{best} , in every repetition, particles update their position and velocity according to below relationships (step7).

$$v_i = wv_i + c_1 r_1 (p_{best} - x_i) + c_2 r_2 (g_{best} - x_i) \qquad (1)$$

$$x_i = v_i + x_i \qquad (2)$$

In which (i) is 1 to n and (n) is equal to number of population particles (swarm size), (v_i) is velocity of ith particle, (x_i) is position of ith particle, (r_1 ,r_2) are random numbers, ($c_1 = c_2 = 2$) are learning factors, (p_{best}) is best position of particle, (g_{best}) is best general position between all of particles and (w) is stasis weight value. High value for (w) helps for general searching and low value for local searching. Therefor by linear decreasing (w) from relatively high value to small value may attain to best operation. After updating velocity and position of particles in every repetition, again value of fitness of each particle in new position is calculated (step8). If fitness of new position would be lower than best fitness of particle position in previous repetition, new position of particle would be saved as p_{best} of that particle (step9). Again in every repetition position of best particle with least fitness would be found between other particles, in case that fitness to be lower than fitness of best particle in previous repetition, that position would be saved as g_{best} (step10). Updating processes of velocity and position of particles, calculation of fitness and finding p_{best} and g_{best} will be continued until reaching to stop condition.

Regarding to above mentioned subjects, PSO algorithm is stated as following:

Step1 : Initialize The Size Of The Particles Swarm n

Step2: Initialize x_i And v_i For Each Particle i In
The Population

Step3 : Calculate The Fitness Value Of Each
Particle

Step4: Initialize p_{best}

Step5: Initialize g_{best}

Step6 : While (The End Criterion Is Not Met)

Do **step7** To **step10**

Step7: For Each Particle i Update v_i And x_i

According To Equations (1) And (2)

Step8 : Calculate The Fitness Value Of Each

Particle

Step9 : For Each Particle i :

IF Fitness < Best Fitness Then

$p_{best} = x_i$

Step10 : Update g_{best}

Important matter in this algorithm is that, this algorithm easily will be captured by local minimum. If the number of local minimum points as fitness function to be great, it is enough that one particle would move towards local minimum, since in PSO every particle according to its knowledge and knowledge of its neighbours changes its position, hence other particles also move towards that particle and algorithm easily will be captured by local minimum value. For prevention of this, it is proposed a method so that by removing of particles with low operation and changing of position regarding to $\mathrm{g_{best}}$ and worst solution of each particle, will be possible to move towards general optimum points.

2. PROPOSED METHOD

As it was said in PSO, particles learn from each other in swarm and based on acquired knowledge go towards of their best neighbours and in each step every particle regarding to $\mathrm{p_{best}}$ and $\mathrm{g_{best}}$. But as PSO in this way easily is captured by local minimum, proposed a method of PSO that in addition to reducing of calculations, would cause general searching. The method is such that every particle compares its position according to its previous worst solution and $\mathrm{g_{best}}$ for finding of optimum value [2]. This method would cause general searching. For reducing of calculations for solution of problem, we gradually decrease the population [3]. For doing this only in some of the repetitions of resolving the problem we remove low operation particles. Removing of these particles from population would cause removing of calculations related to them and would result to decreasing calculations in process of solving the problem. For removing of particles with low operation, it is used of selection sort method. Selection sort method found small element of list and replace with first element of list, in next step, from the second place of list and after that, it is found most small element and replace with second element and this process will continue until complete arrangement of list. After arranging of particles based on their fitness by selection sort method, half of particles that had more fitness are removed from population.

According to mentioned principles for this method, steps of this method is stated as following:

This method same as PSO, initiates searching process with some of particles as initial population (step1). Each of particles with random position and velocity would flow in search space (step2). By attention to defined fitness function, fitness value of any particle is calculated based on considered function (step3). Between particles, the particles that have lower fitness are recognized as g_{best} (step4). Worst position that particle actually has been placed in that, is called p_{worst} .Therefore p_{worst} of each particle is equal to that position in which particle has most fitness (step5). In this method it is considered maximal repetition numbers that until maximum repetition, solving of problem will be continued (step6). In this method with the aim of reducing calculations, half of the particles in some of the repetitions should be removed from population (step7). If we reach to considered repetition during the solving of problem, by using of selection sort method, particles with low operation will remove from population. For doing this, since fitness of best position of each particles, by using of selection sort method, fitness elements are arranged ascendantly (step8). After ascending arrangement, half of particles that have more fitness, are removed from population (step9). In this method in every repetition every particle updates its position and its velocity (step10) according to g_{best} and p_{worst} as following:

$$v_i = wv_i + c_1r_1(p_{worst} - x_i) + c_2r_2(g_{best} - x_i) \qquad (3)$$

$$x_i = v_i + x_i \qquad (4)$$

In which (i) is from 1 to n and (n) is equal to number of population particles (swarm size), (v_i) is velocity of ith particle, (x_i) is position of ith particle, (r_1 , r_2) are random numbers, ($c_1 = c_2 = 2$) are learning factors,(p_{worst}) is worst position of particle, (g_{best}) is best general position between all of particles and (w) is stasis weight value. For better operating of this method, (w) value linearly decreases in each step. After updating velocity and position of particles in any repetition, again fitness value of each particle is calculated in that position (step11). In any repetition position of best particle with least fitness is found among the other particles, as the fitness of it to be lower than best position in previous repetition, that position will be saved as g_{best} (step12). If the fitness of each particle in new position to be more than worst fitness of that particle in previous repetition, that new position will be saved as p_{worst} of that particle (step13). The process of updating the position and velocity of particles will continue until maximum repetition and process of removing particles with low operation also are repeated in specified repetitions. The reason that particles are removed only in specified repetitions is that, if in every repetition would removed half of particles of population, population would be destroyed after some repetition.

Regarding to mentioned subjects algorithm of new method is stated as following:

Step1 : Initialize The Size Of The Particles Swarm n

Step2: Initialize x_i And v_i For Each Particle i In The Population

Step3 : Calculate The Fitness Value Of Each Particle

Step4 : Initialize g_{best}

Step5: Initialize p_{worst} For Each Particle

Step6 : While (The End Criterion Is Not Met) Do

step7 To **step13**

Step7 : While (Dropping Iterations) Do

step8 To **step9**

Step8 : Sorting Best Fitness Values

Step9 : Deleting Particles

Step10: For Each Particle i Update v_i And x_i

According To Equations (3) And (4)

Step11 : Calculate The Fitness Value Of Each

Particle

Step12 : Update g_{best}

Step13 : For Each Particle i :

IF Fitness > Worst Fitness Then

$p_{worst} = x_i$

According to mentioned principles about new method and PSO algorithm in this section, we compare results of both methods for finding optimum value of a function. As the aim of this method is general searching and reducing of calculations, for testing should be selected a function that to has many local minimum. For doing this has been selected “Weierstrass” function. As it is shown in (**Figure 1**) this function has many of minimum points.

Weierstrass function for *n* dimensional problem is as following :

$$f(x) = \sum_{i=1}^{n} a^i cos(b^i \pi\, x) \qquad (5)$$

And behavior of function is as:

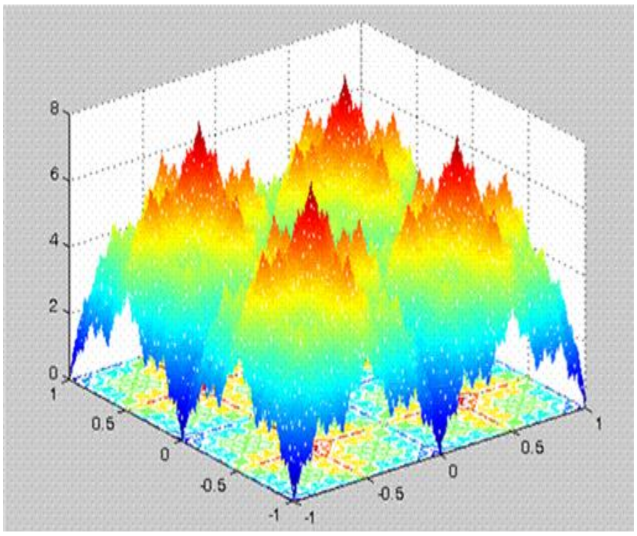

Figure 1 . Behaviour Of Weierstrass Function

Testing is as following:

For comparing of PSO with new method, we consider same conditions for both methods. First time for swarm size in both methods we put equal to 100 particles, maximum of repetition in both methods is equal to 100. PSO regarding to p_{best} and g_{best} searches and new method searches based on p_{worst} , g_{best} and gradual diminishing population in 20,40,60,80 repetitions.

For 40 times performance, we examine each of methods and obtain average of results. We call new method NPSO-DP. Average value of optimum of PSO and NPSO-DP methods for weierstrass function in 40 times performing with 100 particles and maximum repetition of 100 in each of 2 to 5 dimensions is as following :

Table 1. Comparison Of PSO and NPSO-DP With 100 Particles

Dimension	Algorithm	
	PSO	**NPSO-DP**
2D	0.0121	2.6983e-004
3D	0.0473	0.0331
4D	0.3310	0.1526
5D	0.7665	0.2493

For second time we increase swarm size to 1000, maximum of repetition in both methods is equal to 100, PSO searches by considering p_{best} and g_{best} , NPSO-DP searches based on p_{worst} , g_{best} and gradual diminishing population in 200.400,600,800 repetitions. We examine each of methods for 40 times performance. Average value of optimum for both methods in weierstrass function in 40 times performing with 1000 particles and maximum repetition of 100 in each of 2 to 5 dimension is as following :

Table2. Comparison PSO And NPSO-DP With 1000 Particles

Dimension	Algorithm	
	PSO	**NPSO-DP**
2D	0.0014	5.5411e-007
3D	0.0151	2.6633e-005
4D	0.0648	0.0054
5D	0.1600	0.0014

The results show that PSO in such functions with high local minimum is captured local optimum value and NPSO-DP in each of problem dimensions with any size of population obtains better optimum value than to PSO.

4. CONCLUSION

In this paper has been presented a method for improvement of PSO algorithm searching process, that searching with attention to worst and best position. Along with this method for reducing of calculations, along with specified repetitions, would remove a number of particles with low operation. Since PSO in solution of complicated problem with high local minimum are captured by local minimum, according to obtained results, this method works very well and helps to general searching.

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