To Main Proceedings Document

Genetic Simulated Annealing Algorithm With Selective Generation

Hongqian Liang, Junzhi Cui
Institute of Computational Mathematics and Science/Engineering Computing, Chinese Academy of Science
lhqian@lsec.cc.ac.cn

Abstract:

The general Genetic Algorithm has the weakness of premature and poor ability of local searching and general Simulated Anneaing doesnot have fast speed of global searching. The paper uses the conception of selective generation,designs an algorithm accompanying Genetic Algorithm and Simulated Annealing, which improves the searching speed and avoids the premature. Computing results of optimizing some hard-optimizing functions show that the method has more fast conver-gence speed.

Keywords:

Genetic Algorithm, Simulated Annealing, Selectivity Generation, Reproduction Operator, Optimization

1 Introduction

Genetic Algorithm(GA)[1]is a effective solution of problems of optimization.It was introduced by John Holland in 1975.After 1975• it has been developed to general computing model of resolving problems of optimization by simulating evolving process of the nature.

Simulated Annealing(SA)[2] is introduced to combinational optimization by Kirkpatrick in 1982.SA can effectively resove problems of Nondeterministic Polynomial Completeness.

The GA has ability of global searching,but is poor in local searching.For example,if the population is near the optimization,the algorithm also wastes much time for this optimum value.What's more,GA is easily convergent to the local optimization.SA can fast find the local optimization, however, the ability of global searching of the algorithm is despondent.In some cases,The GA and the SA can be corporated to resolve problem of optimization. Such methods are introduced by paper[4] and paper[5] and resolve a lot problems which can not resolve well by only one. However,when resolving a variety of engineering problems through such methods, people find the results still cannot satisfy the requirements,such as premature, convergenve to local optimization and poor speed of global searching. Paper[3] introduces a conception of selective genration, which selects some individuals with fine genetic modes in the current generation to reproduce and at some degree voids randomness and blindness of reproduction to speed computation. This paper use the concetion of selective generation,based on the GA and the SA,introduces the genetic simulated annealing algorithm with selective generation, which can select some special individuals for reproduction and improve the searching speed, Meanwhile,improves the method provided by paper[3], greatly avoids randomness and blindness of reproduction to speed computation.

Now the method provided by this paper has been used for load forecast in electric power

---

This paper is Subsidized by the special funds for major state basic reseach projects.
Project No:G1998030416

system.It is proved that the method has high convergent speed of searching.

2 Construct Genetic Algorithm with selective generation

The method provided by this paper uses individuals with real-coded.

1 Define the fitness function

$$F(x) = e^{-\alpha(f(x) - f_{\min}(x))}$$

$f(x)$: the object function

$f_{\min}(x)$: the minimal value of the object function of the current population.

α : control parameter

The definition of the fitness function guanrantes non-negativity and maximization.While • decreases, the probability of the dividuals with high fitness to be selected increases.

2 Define the operator of selection

The strategy is first to select minimal individual and maximal individual into matching set, then to select other individuals with the method of competence between two,which is to randomly select two individuals from current population and put the maximal individual into matching set,repeating the transaction above until the quanitity of the individuals of matching set arrive at the number given.

This definition of operator of selection guanrantes the current maximal individual unconditionally comes into matching set and competence between two avoids the problem of Super Number String[6] and of Close Competence of the Proportional Model[6],what's more,in this method, to select the minimal individual to guanrantee the diversity of the population and reserve fine gene mode.

3 Define operator of crossover

Firstly,the maximal individual and the minimal individual perform one-point crossover: randomly select a point in the real-coded string of individual for crossover,then exchange the matching chorosomes of two individuals at the point, at last put the results of crossover into matching set.

Secondly,other individuals of matching set perform arithmatic crossover and one-point crossover.

For example, select individuals A and B belonging to the matching set to be parent individuals.The arithmatic crossover between two is following:

a =□A+(1-□)B

b =□B+(1-□)A

parameter □ is a real in[0,1],may vary according to the fitness of A and B.If A is proximately similar to B, □could be a large number,on the other hand, □could be a small number.The arithmatic crossover of A and B produce two children,a and b.

Meanwhile,A and B perform one-point crossover,which also produce two child individuals.

Finally put four child individuals and their parents,A and B,into matching set.

The style of definition of operator of crossover between the maximal individual and the minimal individual guarantes the minimal probabilities of destruction of fine genetic mode by one-point crossover. crossovers of other individuals of matching set by one-point crossover and arithmatic crossover are available to produce more individuals in the next generation to increase diversities of individuals and to decrease probability of similar individuals presented.

4 Define operator of mutation

The maximal individual and the minimal individual perform non-homogeneous mutation[3] : given parental individual

$$X = x_1 x_2 x_3 \ldots\ldots x_n$$

x_k = (k = 1,2,3, …… n) is the point for mutation, the definition field of x_k is [A_k B_k].so new genetic value is decided by the following formula•

r is a random number homogeneously distributed in [0 ,1]•t is the number of the generation•T is the given gross quanitity of the generations.• is the parameter preciously given and might vary according to information of the current generation,in some beginning generations, • could be a

$$x_k' = \begin{cases} x_k + \Delta(t, B_k - x_k) & rand(0,1) = 0 \\ x_k + \Delta(t, x_k - A_k) & rand(0,1) = 1 \end{cases}$$

$$\Delta(t, y) = y(1 - r^{\beta(1 - \frac{t}{T})})$$

large number,and in some ending generations, • could be a small number. The result of rand(0,1) is equally probablly 0 or 1.Finally put the results of mutation of individuals and their parent X into matching set.

Concomitly, other individuals of matching set also perform non-homogeneously mutate on probability of mutation and put the results of mutation of individuals and their parents into matching set.

The method compulsivly mutates the maximal individual can speed searching the local maximal value by the mutation of maximal individual,Otherwise the mutation of minimal individual can increase diversity of the population to avoid the premature of Genetic Algorithm(GA).To maintain random of operator of mutation,the parent population should non-homogeneously mutate on the probability of mutation,then put the results of the mutation of individuals into matching set.

5 Define operator of simulated annealing

Firstly select maximal individual from current generation, perform it with operator of simulated annealing, receive new result according to probability:

$$y = \min(1, e^{\frac{f(i) - f_0}{T}})$$

$f(i)$ is the value of the fitness function of new result, f_0 is the value of the fitness function of maximal individual of current generation, ³ which decreases by formula ³ $= \alpha$ ³ is the current degree of temperature of algorithm of simulated annealing.

During the process of the computing,preserve every optimization of every Markov chain to certain value of T. The maximal resolution of the optimizations preserved is the final result.

Finally,put the result of simulated annealing into matching set.

This definition of operator of simulated annealing guanrantes firstly to search the local maximization near maximal individual. Because the algorithm of simulated annealing has powerful ability to search the local maximization, the operator can save much time and soon determine whether the local maximization is the global maximazation or not.Meanwhile, preserving the optimization of every Markov chain can avoid acquiring non-optimum resolution.

3 Construct Algorithm

Properly organizing the operaters of reproduction above,the paper gets an effective algorithm which can effectively resolve many hard-optimizing problems. Through genetic stock to preseve individuals with fine gene modes,the algorithm can effectively avoid plunging into local optimization and fast get the global optimization.

The algorithm constructe d is following :

1 initialize the generation counter : $t \leftarrow 0$.

2 create randomly t he original population P(t).

3 perform operator of selection : $P(t) = selection\ [P(t)]$.

4 perform operator of crossover : $P^{'}(t) = crossover\ [P(t)]$.

5 perform operator of mutation : $P^{''}(t) = mutation\ [P(t)]$.

6 perform operator of simulated annealing : $\alpha = Simulated\ \ Annealing\ [P(t)]$.

7 perform operator of selection : $P(t+1) = selection\ [\{\alpha\} \oplus P^{''}(t) \oplus P^{'}(t) \oplus P(t)]$.

8 make a judge whether t he method should be stopped, if no, return to 4, if yes, output the optimizati on and stop the computing process.

4 Computing example

Given the minimal value of the Shubert function.

$$f(x_1, x_2) = \prod_{k=1}^{2}\left\{\sum_{i=1}^{5} i\cos[(i+1)x_k + i]\right\}$$

the global minimal value of the function of Shubert is -186.73099 and the number of the point with the global minimal value is infinite.The following is to resolve the minimal value of the function by the method provided above and to compare with processes of Simple Genetic Algorithm•SGA•,Real-coded Genetic Algorithm•RGA•and method given by Paper[3].In the method given by paper[3] and the method given by this paper,Pc=0.8,Pm=0.01,scale of population is 100,the most number of generation is 50, □ chooses 0.4 and 0.6, • chooses 0.6 or 0.8, the field of definite of variables x1,x2 is [-10,10] .

The following table represents the diference of SGA,RGA,the method by paper[3] and the method given by this paper.

Name Of Algorithm	SGA	RGA	Method by Paper[3]	The Given Method
Number Of Generatior	112	81	50	45
x	-0.802	-7.08313	-1.42514	-0.80035
y	-7.70874	-1.42517	-7.0835	4.85803
f(x,y)	-186.73	-186.7304	-186.7304	-186.7309
time(s)	2.34	1.88	0.67	0.63

Therefore,the computing time of the method introduced by this paper is more less than the SGA, the RGA,the method given by paper[3] and the precision better than those.

5 Conclusion

The paper deeply analyses random which can resulted in waste of computing time and the local optimization and all kinds of currently operators of reproduction•operator of selection• operator of crossover•operator of mutation•of a varity of the Genetic Algorithm(GA),then introduces the conception of selective generation.

1 The operator of selection puts unconditionaly the dividuals with the maximal fitness and the minimal fitness in order to maintain the diversity of individuals.

2 The fitness function is defined by exponential function to guanrante non-negativity, and constrain parameter • is used to control optimization of individuals.

3 Using conception of selective generation to define special operator of reproduction•operator of selection•operator of crossover•operator of mutation•,compulsivly select maximal and minimal individuals from current population for selection•crossover and mutation to avoid phenomenon of premature•to speed computation.

4 Accompanying the algorithm of Simulated Annealing,the method can soon search out the optimization near the maximal individual of the current population then decide whether it is local optimization or not,which is advantaging of jumping off the the local maximization.

5 After computing some engineering examples,we can find this method has high performance of global searching and local searching.

References:

[1] Holland J H. Adaptive of Natural and Artificial Systems. Ann Arbor•The University Of Michigan Press,1975

[2] Kirkpatrik S etc. Optimization By Simulated Annealing. Science, 1983, 220: 671~680

[3] Hongqian Liang etc. Genetic Algorithm With Selective Generation. APGA2000, HongKong, 2000

[4] Chen H,Flann N S. Paralled Simulated Annealing and Genetic Algorithm: A Space of Hybrid Methods. In: Paralled Problem Solving from Nature 3, Springer-Verlag, 1994, 428~438

[5] Grefenstette J J. Incorporation Problem Specific Knowledge into Genetic Algorithm. In: Davis L Ed. Genetic Algorithms and Simulated Annealing, Pitman, 1987, 42~60

[6] Han zhenxiang etc. Optimization Method of Simulating Evolution and Application. Computer Science,1995•2•47~56