Study of Multi-project Conflicts by IGA Based on the Improvement of Fitness Function

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Abstract— **In the multi-project resource conflicts exist in the application of standard genetic algorithm fitness function exist "premature" problem, Genetic algorithm can not find the convergence of these issue. Based on the above issues ,an improved genetic algorithm (IGA) are appropriate, From the fitness function, mutation and selection methods to improve two aspects are described, the Improved genetic algorithm for simple genetic algorithm has the advantage of generations of each evolution, offspring parent always retains the best individual to the "high-fitness model for the ancestors of the family orientation" search out better samples, and verified through experiments the effectiveness of the algorithm**

Keywords-component; fitness genetic algorithm; multi-project conflict; improved; multi-project management; optimization resource

I. INTRODUCTION

Genetic algorithm, i.e. GA [1], is a type of self-organized and adaptive artificial intelligent technique which simulates biological evolution process and mechanism in the natural world to solve extreme values. It can provide means and common framework which are effective for settling optimization problems. It can be said a brand new global optimization search method.

In the paper [2], conventional optimization methods are believed to seek for the optimal solution by iteration of a single initial value, which would easily fall into the locally optimal solution. Comparatively, genetic algorithm starts search from series set, being of a very wide range, which is good to find the global optimum. Its other merits are also noticed in [3], which points out that the fitness function of GA is free from the continuous differentiability and also the domain of definition being set arbitrarily. Such a feature makes it extensively applicable.

II. RELATED WORK

A. the environment and process of the test

Multi-project management is the assembly of a group of resources. Competition among various projects is for the fight and exploitation of resources. To enterprises, it is much more essential that they should have the ability to run multiple projects concurrently. Lots of difficulties lurk in the multi-project management, which were not overcome through techniques with regards to the single project management in the past. If it is unlikely to manage and allocate resources of all items uniformly and effectively across the entire organization, conflicts and disputes will be inevitably occur as a result of the strive for limited key resources among those projects. Yet, such conflicts are dependent on characteristics of resources, which refer to:

1)Resources are valuable [4]: any resource is worthy; the excessive occupation of resources will cause idleness and waste; or the inappropriate utilization will cost you much more in order to achieve the goal of projects;

2)Resources are limited [5]: it’s the same with any resource; so it is improbable to use them simultaneously in several projects any time at any place; for the project management, if resources can’t be reasonably distributed nor effectively balanced, intense conflicts will absolutely arise among projects in the competition.

The core issue to multi-project management rests with how to enable the best allocation of restricted resources, which otherwise requires resource allocation management for many projects. For the reason of cost, proficiency, time and competition, almost all projects are constrained by resources. So far, as to the project management, the concern of most papers is about time, without attentions to the possibilities and availability of resources as well as their association with the progress of such projects. Due to the improper collocation among human resources, instrument, machine, site, device and tools, projects are frequently postponed at the critical moment. In addition, if projects are not well managed, manpower cost will be incremental with the put-off or members’ extra work. The cost of equipment would be increased too because of in-advance leasing or necessary appreciation.

Compared with other optimization methods, GA has its specialties like [6]:

1)Instead of operating from single initial value, which is common to traditional optimization methods, GA begins search from series set of solutions to problems, which is the most distinct. According to the comparison by test function, it easily falls into the locally optimal solution but the globally optima not be obtained;

2)Those methods are performing one-by-one search function, while GA is able to search multiple possible values in the solution space through multi-point crossover, avoiding falling into the local optima. Specifically, GA makes fitness evaluation of solutions in the solution space after setting some chromosomes and intercrossing them, decreasing the likeliness of falling into the locally optimal solution;

1)Another feature is GA uses fitness function to evaluate individuals. Generally speaking, fitness function is target function, which simplifies the design process of GA. Yet, the design process is fulfilled through conventional optimization methods with some assisted ones. The domain of definition of GA's fitness function cannot be affected by continuity but be freely defined [7];

2)GA's mutation uses probability, which ensures the succession between the last and next generations. It is different from the fixed search rules followed by traditional optimization methods.

3)GA simulates fully features of biological evolution in the nature. The next generation is inheritable from the past and offspring can learn from their parents and get adapted to changeable environment. Besides, genetic algorithm makes full use of information acquired during the evolutionary process to self-organize search. Thus, individuals with higher degree of fitness can get higher possibility of survival and chromosomal structure more adaptive to the environment, as to eventually find the best solution.

By virtue of the above merits, genetic algorithm can be applied in a wider and wider range and gain increasing attentions from researchers.

Since GA does not pose many requirements mathematically for the optimization of obtained solution, but only takes advantage of value information of target function, well fit for combinatorial optimization, it will help resolve resource conflicts among multiple projects unless an appropriate coding scheme and GA operator are devised and the completeness of the solution space is assured, to bring forth an approximate optimal multi-project progress plan. That is what we should work out here.

B. Solutions

In the improved genetic algorithm, i.e. IGA, three improved operators usually perform crossover operations, selecting randomly two chromosomes to carry out single point crossover operation or other crossover operations such as multi-point crossover. The single point crossover is one-sided as it just picks up one point from the "family" whose ancestor has better adaptation. Simple GA is demonstrated to be not convergent in any case (crossover probability *Pc*, mutation probability *Pm*, any initialization, any crossover operator and any fitness function), i.e. unable to search the globally optimal solution. Although the improved GA is testified to converge to ultimately get the optimal solution, it would take a long time. Moreover, prematurity should not be overlooked in GA.

1)Improvement of fitness function

Fitness function is used to evaluate the adaptability of individuals to environment, which is the foundation for operation selection and has direct influence on the performance of genetic algorithm. Fitness function is transformed from target function, for the common goal of retaining much more individuals with higher fitness. However, in order to achieve the global optimization and avoid pre-mature convergence, it is advisable to maintain varieties of individuals as much as possible during the selection. Guided by the idea, in order for those individuals with lower function values during earlier evolution to be selected more probably, it's necessary to keep diversities of the population for the avoidance of pre-maturity; while during anaphase, you can turn to normal selection operation and begin searching the locally optimal solution. Here, fitness function is improved into:

$$f'(x_i) = \begin{cases} \left| f(x_i) - \overline{f} \right| & t \le 0.6T \quad (1) \\ \tan\left(\frac{t}{T} \bullet \frac{\pi}{4} \bullet f(x_i) + f_{\max}\right) & t \ge 0.6T \quad (2) \end{cases}$$

where, $f_{\max}$ is the function value of the best solution in the last generation; t is current iterations; T is the maximum preset iteration.

2)Improvement of both mutation method and selection method

For such improvements, importance should be attached to the following points:

- Determine dynamically mutation probability: it's likely to protect superior genes from damage during mutation and introduce new genes to the population when it falls into the locally optimal solution;
- Improve selection method: it's possible to prevent individuals with higher fitness at the early stage from taking up the population quickly and the population at a later stage from stopping development owing to the fact that individuals' fitness is not quite different from one another. Roulette selection method allows for each individual to get support, which can't show the competitiveness of good individuals, not in conformity with the principle of "survival of the fittest" of GA. For that reason, we use a population-based selection method to replace the roulette selection, which works according to individuals' fitness.

III. Description and Improvement of The Proposed Method

A. Improvement

When used to solve the problem of convergence, preferential crossover generally takes the strategy to limit competitiveness of excellent individuals, i.e. colonies of those with higher fitness. It will undoubtedly decelerate the rate of evolution, increase time complexity and degrade performance of algorithm. In light that the diversity of population's genes can fall into the local optima and speeding up the evolution of population can help improve the overall performance of the algorithm [8], in order to overcome such a conflict, it is recommended to try a method which would accelerate the speed of evolution of population without causing damages to genes' varieties. The method is depicted as: choose randomly male and female parents to cross over for n times by using the method such as single point crossover, multi-point crossover and uniform crossover as to generate $2n$ individuals, from which the best two individuals are selected out and added into a new population. It not only save genes of both male and female parents, and also enhances the average performance of individuals during the evolutionary process.

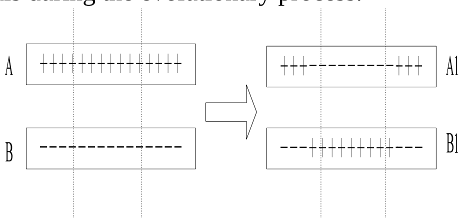

Figure 1. Schematic Diagram of Two-point Crossover

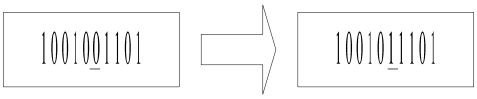

Figure 2. Schematic Diagram of Mutation

Based on the above analysis, the improved GA can be expressed like:

Step 1: in the initialized population, sort all individuals according to their degree of fitness and then compute respectively their support and degree of confidence;

Step 2: make colonies at certain proportion, i.e. copy wholly the structure of two individuals which have the highest fitness in current population to the population to be mated with;

Step 3: based on the location of an individual determine its mutation probability and perform mutation operation; follow the rule of "four copies of the superior and none of the inferior" to make duplication of individuals;

Step 4: select randomly two individuals from those copies and perform multiple crossover operations; from resultants, choose one best individual and add it to a new population;

Step 5: if it meets conditions, stops it; or, turn back to Step 1 till rules which meet all conditions are found.

The advantage of the improved GA over simple GAs rests in that during every evolution of each generation, filial generations always preserve the best individuals of parent as to search better samples in the family with the mode of high fitness as ancestor, which therefore guarantees the search of the globally best solution in the end.

B. *Experimental Test of the Algorithm*

In the experiment, we used two typical functions to make tests and made comparisons between IGA and GA. In the definition domain of both functions, there is only one globally minimum value f (0.0)=0. The two functions are expressed as:

Test function 1:

$$f(x_1, x_2) = (x_1^2 + x_2^2)^{0.25}[\sin^2(50(x_1^2 + x_2^2)^{0.1}) + 1],$$

$$-100 < x_1, x_2 < 100$$

Test function 2:

$$f(x_1, x_2) = 0.5 + \frac{\sin^2\sqrt{x_1^2 + x_2^2} - 0.5}{[1.0 + 0.01(x_1^2 + x_2^2)]^2},$$

$$-100 \le x_i \le 100, \quad i = 1,2$$

Tests were taken by advantage of IGA and GA on both test functions and comparisons were made on their average values, the optimal solution as well as convergence.

The experiment was carried out in Matlab environment for 30 times, with the population size 100 and evolutionary generations 80.

Test function 1: set precision 1e-5 and run each algorithm separately for 30 times; we can see results in Table 1.

TABLE I. COMPARISONS OF RESULTS BY TWO ALGORITHMS

Two Algorithms	Comparisons			
	Average Time (S)	Average Value	Optimal Value	Number of Optimal Solutions
GA	2.131	0.037	0.015	4
IGA	4.343	2.5e-2	0.002	9

Test function 2: set precision 1e-20 and run each algorithm separately for 30 times; results are shown in the following table:

TABLE II. COMPARISONS OF RESULTS BY TWO ALGORITHMS

Two Algorithms	Comparisons			
	Average Time (S)	Average Value	Optimal Value	Number of Optimal Solutions
GA	3.102	0.0089	1e-10	2
IGA	3.780	5e-18	0	9

It's noticeable from the results, when the precision is low and the time of operation is equivalent, IGA shows a higher degree of accuracy than GA; when the precision is high, and the operation time of IGA is longer than GA, results obtained are much better than by GA.

Both GA and IGA find the globally optimal solutions at an approximate probability. From those comparative results, we can learn that it is more likely for IGA to obtain the optimal solutions globally, uneasily falling into the local extrema.

Just according to the above analysis, we can conclude that IGA is well fit to solve the problem of the global optimization. In the next section we'll discuss its practical application in the multi-project case.

IV. EMPIRICAL ANALYSIS OF THE PROPOSED METHOD

For the purpose of validating its effectiveness, we demonstrated it in the e-government project of Yancheng e-government office. Hereunder is the basic information of that project.

Yancheng e-government office needs three software sub-items to execute at the same time, which are backstage management system (tem 1), inner information management system (item 2) and portal system item (item 3). They have altogether 24 R&D engineers, who are not functionally specified in terms of project requirement analysis, encoding and test but can all join in such three tasks. In addition, there are 20 computer sets for those items, 15 of which are to be used by R&D staffs, while the rest is for administrative, financial and training purpose.

For the design of such an e-government software system, R&D personnel, computer and fund are the frequently-availed resources, which become the key constraint during the project operation.

Since the focus of this paper is on the distribution mechanism of resources among different projects, it is acceptable to ignore the nature of resources but substituting one for another during the construction and solving of models. We'll discuss in detail the resource collaborative system of the aforesaid project and parameters of each individual sub-items.

Backstage management system: it needs to perform functions like:

- Information browsing and retrieval
- E-mail sending and receiving
- Backstage maintenance

By analyzing multi-project management system in the above and according to the actual situation of resource collaboration of Yancheng e-government engineering, we established the logical model of that system.

Use a 17-bit binary system to stand for chromosome, e.g.: 10010101001110110;

The size of population is 100;

The biggest evolutionary generation T is 50;

Crossover probability is 0.01;

Fitness function is

$$f'(x_i) = \begin{cases} \left| f(x_i) - \dfrac{\sum_{i=1}^{u} f_i}{u} \right| & t \le 0.7T \\ \tan(f(x_{i-1})_{\max} + \dfrac{t}{T} * \dfrac{\pi}{4} * f(x_i)) & t \ge 0.7T \end{cases}$$

Here we used Matlab tools together with GA language to modify the process of GA to acquire the improved genetic algorithm. By improving the process of GA, we acquired optimal solutions, which are presented in Figure 3.

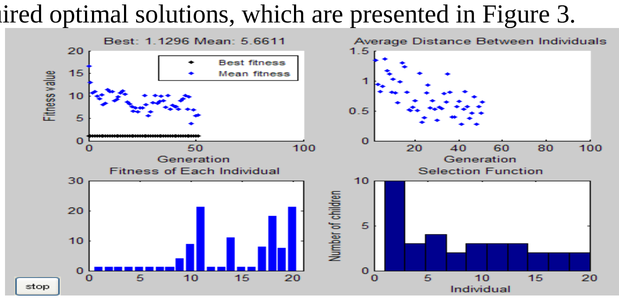

Figure 3. Depiction of Results by the Algorithm

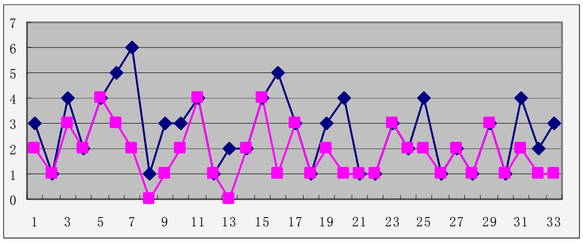

Figure 4. Efficiency Comparisons of Two Algorithms

Resource consumption before and after the optimization and network chart are seen in Figure 4.

V. CONCLUSION

In the paper, it proposed an improved genetic algorithm based on the modification of genetic algorithm, which was used to solve the problem of multi-project conflicts. The strategy was found to be more suitable for resource conflicts among multiple projects. Experiments justified that it's useful for upgrading the quality of initial solutions and ensuring their varieties. Additionally, under the premise of crossover and mutation operations being exerted on genetic algorithm, illegal individuals were avoided. The improved mutation operation boosted the search ability of that method and improved the search efficiency.

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