Research on Dispatching Problem of Maintenance Personnel

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***Abstract*—When the enterprise received the service request from the customer, firstly it will collect the maintenance services at the same time for generating the task list, and then match the right person to perform the task to meet custom needs. Therefore, it is a key issue for the enterprise how to select maintenance staff efficiently. As to the issue, it is established a single target path optimization mathematical model of the maintenance personnel, in the coordinates for breakdown maintenance of Beilin52 location, based on analyzing the drawback of the genetic algorithm, by judging the individual similarity, to increase the diversity of population. Finally, the results of traditional genetic algorithm and improved genetic algorithm are compared, greatly improving the speed of convergence to prove the validity of the model and algorithm.**

Keywords-maintenance services; the improved genetic algorithm; path optimization.

I. INTRODUCTION

Although genetic algorithm does not rely on the gradient when dealing with complex optimization problems, there is a very high robustness and global search capabilities, with broad applicability. However, if inappropriate selection, crossover and mutation way, the traditional genetic algorithm will be appear more iterative times, slow convergence speed, easy to be problems, such as local minimum.

In order to solve these weaknesses of genetic algorithms, many scholars put forward many improved methods: The literature [1] improves the selection operator, by allowing the parent offspring competition tournament selection operator. The improved algorithm can quickly close to the optimal solution. The literature [2] first priority integrated clustering analysis, construct a stochastic switch, and control the mutation operation in genetic algorithm, to increase the population diversity. G. H. Zhang designed a kind of global search, local search and random initialization method of combining [3]. It is improved the search speed and quality. Y. Dai Proposed adaptive crossover and mutation operation of improved genetic algorithm etc. [4] D. D. Guo analyzed the advantages and disadvantages of simulated annealing algorithm and genetic algorithm, these two algorithms are combined to remedy the defects [5]. According to the global search ability of genetic algorithm and convergence speed of particle swarm optimization, M. Jin proposed a genetic algorithm and particle swarm multi-layered hybrid algorithm [6]. The Quantum genetic algorithm is described in the literature [7]. The mainly concepts of quantum computation is introduced into the genetic algorithm. M. M. Zhai proposed that merged into the field of genetic algorithm[8], the ant colony algorithm update the pheromone of ant colony algorithm principle variation rules, effectively improve the efficiency of the optimization of the algorithm, the quality of the optimization to understand.

II. SCHEDULING MODEL

Assuming we know the n fault point coordinates, a maintenance person from one place starting to the rest several fault repairs, each point of failure to once and only once, and finally returned to the original starting point, let him take the shortest route.

$$\text{Min} \quad D = \sum_{i=1}^{n} d(V_i, V_{i+1}) + d(V_n, V_1) \tag{1}$$

Where, $d(V_i, V_{i+1})$ is the distance of the fault point V_i to V_{i+1}.

To position Beilin52 [9] as the fault repair locations, find out the shortest path. Where, Beilin52 coordinates are shown in table 1.

TABLE I THE POSITION COORDINATES OF BEILIN52

Number	Abscissa	Ordinate	Number	Abscissa	Ordinate
1	565	575	27	1320	315
2	25	185	28	1250	400
3	345	750	29	660	180
4	945	685	30	410	250
5	845	655	31	420	555
6	880	660	32	575	665
7	25	230	33	1150	1160
8	525	1000	34	700	580
9	580	1175	35	685	595
10	650	1130	36	685	610
11	1605	620	37	770	610
12	1220	580	38	795	645
13	1465	200	39	720	635
14	1530	5	40	760	650
15	845	680	41	475	960
16	725	370	42	95	260
17	145	665	43	875	920
18	415	635	44	700	500
19	510	875	45	555	815
20	560	365	46	830	485
21	300	465	47	1170	65
22	520	585	48	830	610
23	480	415	49	605	625
24	835	625	50	595	360
25	975	580	51	1340	725
26	1215	245	52	1320	315

III. THE IMPROVED GENETIC ALGORITHM

In order to improve the convergence speed of genetic algorithm is slow, strengthen its global search ability, and keep the diversity of the population. The genetic algorithm is improved in this paper, when the traditional genetic algorithm in optimization calculation is not global convergence, often get the local optimal solution. The main way to improve the genetic algorithm premature convergence is to expand the scope of the search, to maintain the population diversity.

In this paper, how to keep the population diversity is studied and improved. First of all, judge the similar degree of individual, eliminate some similar individuals, reduce the running time, and improve the convergence speed. Retained relatively high fitness individuals, crossover and mutation operations, to increase the diversity of population.

Figure 1 is a flow chart of the improved genetic algorithm:

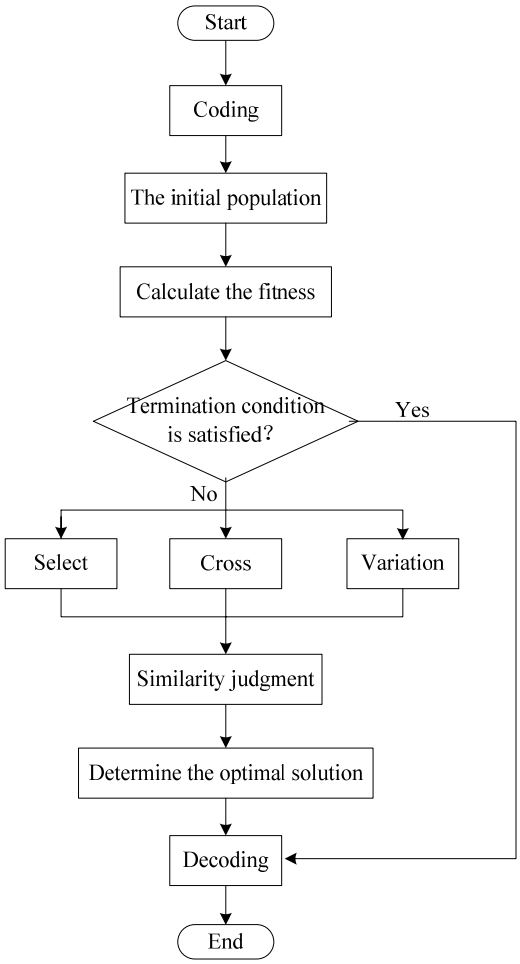

Figure 1. The Flow chart of the improved genetic algorithm

The specific steps are as follows:

STEP1: Set the size of the population initialization NIND，maximum operating algebra MAXGEN, crossover probability P_c and mutation probability P_m;

STEP2: Coding, initial population;

STEP3: According to the fitness function, calculate the fitness values of the individuals in the population, and sorted;

STEP4: Save the high fitness individuals into a population Pop;

STEP5: Perform selection, crossover and mutation operations, to generate the new population pop';

STEP6: Judge the similarity of new populations pop', the removal of similar individuals;

SETP7: Calculate the retained individual to conduct its fitness value, seeking out the best individual;

SETP8: Determine whether the termination condition is satisfied. If satisfied, exit; otherwise, continue the cycle;

SETP9: Output the optimal individual.

IV. Realization method

Coding. This paper uses the integer permutation encoding method. For n points of failure, the chromosome is divided into n parts, each part corresponding to the serial number of a point of failure. For example, an individual in population is: $pop = (1,2,3,4,5,6,7,8,9,10)$.it is showed a total of 10 points of failure, and repair personnel through the 10 points of failure are 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

Fitness function

$$f = \frac{1}{\sum_{i=1}^{n-1} D_{k_i k_j} + D_{k_n k_1}} \tag{2}$$

Where, $D_{k_i k_j}$ is the distance of the fault point k_i to k_j.

Crossover Operator. This paper adopts the method of partial match cross, which determines the position of two intersections, to cross two intersections in the middle of the data. After crossing, retain the right not to repeat the figures, to repeat the figures are part of mapping to eliminate conflicts.

Assuming that the parents are P_1, P_2, randomly selected two points of intersection are $r_1 = 4$, $r_2 = 7$.

$$P_1 : (9\ \ 5\ \ 1 \mid 3\ \ 7\ \ 4\ \ 2 \mid 10\ \ 8\ \ 6)$$

$$P_2 : (10\ \ 5\ \ 4 \mid 6\ \ 3\ \ 8\ \ 7 \mid 2\ \ 1\ \ 9)$$

After crossing into:

$$P_1 : (9\ \ 5\ \ 1 \mid 6\ \ 3\ \ 8\ \ 7 \mid 10\ \ *\ \ *)$$

$$P_2 : (10\ \ 5\ \ * \mid 3\ \ 7\ \ 4\ \ 2 \mid *\ \ 1\ \ 9)$$

Among them, * indicates the presence of duplicate digital individuals. The unselected digitals were inserted to get the offspring P_1' and P_2'.

Mutation. The operation method is adopted by basic bit mutation, randomly selected from two points, and then its location on the exchange. For example, Two point mutation random individual selection of P_1 are $r_1 = 6$, $r_2 = 7$.

$$9\ \ 5\ \ 1 \mid 6 \mid 3\ \ 8 \mid 7 \mid 10\ \ 4\ \ 2$$

After mutation into:

$$9\ \ 5\ \ 1 \mid 7 \mid 3\ \ 8 \mid 6 \mid 10\ \ 4\ \ 2$$

Similarity judgment. To compare any two chromosomes in groups, if there are the same characters and more than half the length of the individual, so that the two individuals are similar.

Such as the individual 9 5 1 6 3 8 7 10 4 2 and 9 5 1 7 3 8 6 10 4 2, the same individual characters is 9 more than half the length of the individual 5, then the two individual is similar.

V. THE EXPERIMENTAL RESULTS

In this paper, the program is running in an Intel Core Intel Core i3-2350M，4GB RAM PC operating system Windows 7 (64-bit), the MATLAB version is 2011 a (64-bit). The parameters are separately Population=200, Crossing Rate=0.9, Mutation Rate=0.05, and the running algebra MAXGEN=200. Partial matching crossover method of genetic algorithm is used to solve Beilin52 data, and finally get an optimal solution. Figure 2 is a random route before optimization. Figure 3 is an optimized route by using the traditional genetic algorithm, and Figure 4 is an improved genetic algorithm for solving the optimization route. Figure 5 is separately using standard genetic algorithm and improved genetic algorithm optimization iteration comparison chart. As can be seen from Figure 5, it tends to be stable when running to 120 generations by using the genetic algorithm. The convergence speed is slow, and get the local optimal solution; he improved genetic algorithm is used to solve the problem, the iteration run to 40 generations, has been basically stable, relatively easy to convergence, the global optimum can be obtained the solution of the problem, and the method is simple, relatively easy to achieve. While the improved genetic algorithm for iterative run to 40 generations has been basically stable, easy to convergence, and can get the global optimal solution. What's more, the method is simple. It is easier to realize.

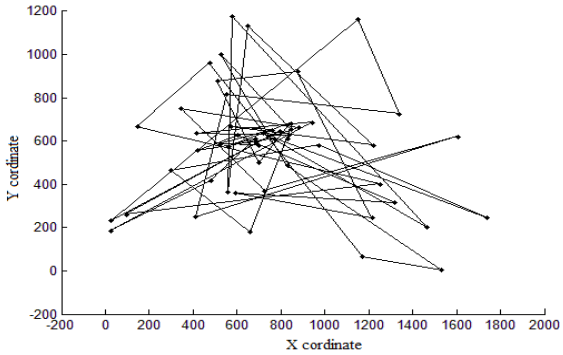

Figure 2. The path before optimization

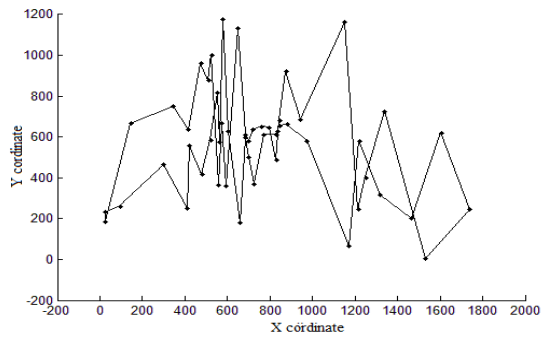

Figure 3. The path after optimization used GA

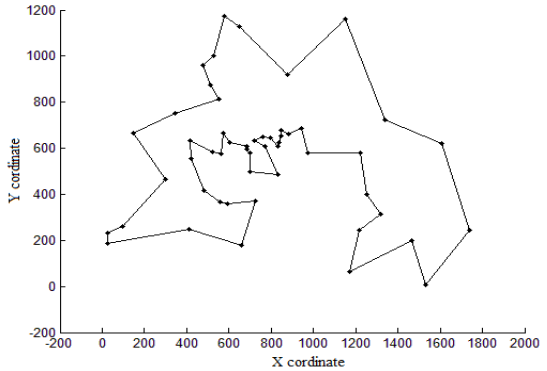

Figure 4. The path after optimization used improved GA

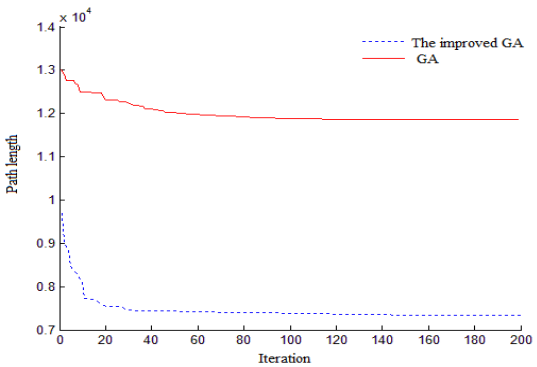

Figure 5. Optimization iteration

The final optimization results and iterative times of genetic algorithm and improved genetic algorithm were showed in table 2. As can be seen from the charts, the improved genetic algorithm can get the optimal solution to much better than the result of the genetic algorithm.

TABLE II. THE COMPARISON OF RESULTS OF GA AND IMPROVED GA

Algorithm	The optimal value	The number of iterations
GA	12052	120
The Improved GA	7525	40

VI. CONCLUSION

In this paper, it is established a single target path optimization mathematical model of the maintenance personnel, in the coordinates for breakdown maintenance of Beilin52 location, based on analyzing the drawback of the genetic algorithm to improve it, by judging the individual similarity, to increase the diversity of population. Finally, the results of traditional genetic algorithm and improved genetic algorithm are compared, greatly improving the speed of convergence to prove the validity of the model and algorithm.

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