Research and Implementation of Tourism Resort Roads Optimal Planning Model Based on Genetic Algorithm

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***Abstract*—After a brief review of the theory involved, results of optimal planning research based on Genetic Algorithm are presented. In this paper, the roads planning in the resort are taken as an example of application in Genetic Algorithm. Modeling the problem with target function and constraint condition to satisfy the minimum construction cost (which is converged to the minimum total length of roads), the problem is solved by using Genetic Algorithm with random operation in MATLAB. I optimize the total length in six cases to get the number and coordinate of "nodes" when these nodes satisfy the minimum total length.**

***Index Terms*—genetic algorithm, optimization, planning model, random operation.**

I. Introduction

Most tourism resorts have special natural scene and cultural landscapes, which need planning requirements corresponding to the tourism resort roads planning in terms of the sustainable development. The eventual optimal roads planning should not only avoid damaging the landscapes but also make the roads construction fee reach minimum in terms of all the roads can reach every scene and landscape.

There are many conventional mathematical modeling algorithms to the optimal roads planning problems, such as floydof the shortest path algorithm, prim and kruskal of minimal spanning tree algorithm, and ordering of optimal depth algorithm. Using these algorithms to solve the problems always has some flaws in terms of the algorithms' working efficiency and generality. Genetic algorithm is a new optimization method which has many strengths, such as exploring the optimal resolution, stochastic control, robustness of high accuracy and convenient application. Those strengths make the genetic algorithm apply in the optimal planning problems commendably [1].

This paper introduces the genetic algorithm dealing with the tourism resort roads optimal planning model.

II. Modeling of Roads Planning

A. Analysis and Hypothesis

The construction fee of all roads is the sum of each road's fee, which is proportional to the length of each road. Then the planning problem on the minimum total fee converts to an optimal planning problem on the minimum total length of all roads. Each length of each road is scaled from a node to another node. The node here is where each road changes its orientation (all nodes here, including the resort entrances, obviously).

I assume that there's a rectangular tourism resort which has eight entrances on the resort border. The number of nodes inside the resort is vibration n. Assumptions also include the following three aspects:

Roads in the resort are all straight lines;

Nodes' length of roads is negligible;

Each node can be simplified as a coordinate in a two dimensional coordinate system.

B. Modeling

As the above assumption said, the number of nodes in the resort is n+8. Then I can calculate the distance between each node. A weighted adjacency matrix *W* (in which the weight of each road is presented by w_{ij}, values of i can be taken as 1-8, and values of j can be taken as 1-7) can be produced by using the distance calculated previously.

According to the analysis and model assumption above, the objective function can be described as follow:

$$\min \sum w_{ij} I_{ij} \tag{1}$$

where I_{ij} is the presentation of the status of link between each node. Using the 0/1 integer programming to describe values of I_{ij} [2], [3], then I can have the following formula:

$$I_{ij} = \begin{cases} 1 & \text{the road from node i to node j exists} \\ 0 & \text{the road from node i to node j dose not exist} \end{cases} \tag{2}$$

As said, the diagonal elements of I_{ij} are all zero, and it satisfies a condition which shows as following,

If I_{ij}=1and I_{jk}=1, then I_{ik}=1.

I add a additional constraint condition to this model for examining the strengths of genetic algorithm. The condition is that the minimum length of roads between each entrance should be no more than the length of the straight link between each entrance.

From above statement, the constraint condition founction can be presented by an equation:

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$$\sum_{\substack{1 \leq i \leq 8 \\ 1<j<7}} w_{ij} I_{ij} \leq 1.4 w_{ij} \qquad (3)$$

III. Genetic Algorithm for Optimizations

A. Thinking of Algorithm

Genetic Algorithms are search algorithms of probability, they are self-adapting and enlightening which imitates evolution principles of biological seminal group in natural world. The group adapt themselves to their environment through nature election and mutation to reproduce generations. This searching method is based on random operation. With long term selections, sustainable members who have the highest adaption in the new generations are the optimal solutions of unknown parameters [4]. Conventional optimal algorithms can only reach the local optimum, and these algorithms require continuous target function. The differentiability of the target function is needed as well. Enumeration algorithm though has overcome such obstacle, the low computing efficiency leads to searching only partial situations in terms of some actual problems with large searching space. The popular dynamic programming also has the "exponential explosion" problem, which leads to its incapability in medium-sized and complicated problems. Genetic algorithms encode the space parameters on random operation, which has improved the searching efficiency [1], [5].

Compared with conventional optimal algorithm, genetic algorithm has the following strengths [1]:

1. Genetic algorithm operates on coded parameters, not the parameters themselves. It encodes the parameters into character strings with limited length, which is based on the limited alphabet.
2. Without limiting to only one point, genetic algorithm performs parallel operations with many points so that the algorithm can effectively avoid converging to local optimization.
3. Genetic algorithm can get the optimal solution with the target function, not including other additional information. This makes the algorithm depends less on the problem.
4. The convenience and wide applying range of genetic algorithm is that it has no limits on the target function.

B. Genetic Algorithm Flow

There's a flow (see in Fig.1) shows the steps of genetic algorithm when using the genetic algorithm to solve this problem [6], [7]. The algorithm and flow is as follows:

1. Initial the parameters in the problem.
2. Encode the parameters to make the first group t.
3. Calculate the optimization, and copy, intersect, and vary the codes to make the second group t+1.
4. Judging that whether the group t+1 satisfy the requirements or not.
5. If the answer to the judgment is "yes", then decode the codes and solve the problem.
6. If the answer is "no", then substitute the group t+1 for group t and go back to the above step to calculate the optimization. Repeat the steps to satisfy the ending condition.

IV. Analysis of Instance based on Genetic Algorithm

According to my previous assumption, the eight entrances of the tourism resort are known. I assume the coordinate of theses entrances are specifically known, they are presented by letters from A to G. There coordinates are as follows:

A(20,0), *B*(50,0), *C*(160,0), *D*(200,50),
E(120,100), *F*(35,100), *G*(10,100), *H*(0,25).

Using the genetic algorithm to solve this optimal planning problem with writing programs in MATLAB, I can get different optimal planning by the random operation [8]. The method and area of operating the random points are defined as follows:

Producing random points in the rectangular area, if the number of points is an odd number, then the procedure of producing random points is in the whole rectangular area; if the number of points is an even number, then the procedure of producing random points is divided into two equal parts of the rectangular area. Fist, let the procedure produce one point, using the genetic algorithm to get an optimal planning. Then let the procedure produce two points (which are divided in two equal parts of the resort area), using the genetic algorithm to resolve the problem and get the optimal planning. When the number of nodes is six, finish the assignment and analyze the outcome.

Several planning are produced by different number of random nodes which is valued from 1 to 6 in the rectangular resort. Six kinds of results in each time the random node is produced are showed in TABLE I.

TABLE I. Six Kinds of Results

Nodes	1	2	3	4	5	6
Length/m	513	360	375	362	378	372

As the table said, the minimum total length of the tourism resort roads is 360m when the number of nodes is two. The optimal roads planning map when the number of nodes is 2 is showed in Fig. 2 (The other 5 planning when the number of nodes are other values are showed in the APPENDIX).

Considering that most tourism resorts have precious nature scene or landscaping, I add a lake which should not be damaged by roads construction in the resort. The random points that the genetic algorithm produces can be in the lake or something else like the scene or landscaping. In these areas, the roads planned by genetic algorithm previously should not cross these areas. There is a new way to solve this problem with the finite condition. To make a new roads planning in the resort which has an area should not be used, I can "dig" the special area and then use the genetic algorithm to solve the problem in the remaining area of the rectangular resort. Using the previous method to resolve the new problem (which is based on the optimal planning with the minimum length of roads) with the finite condition, a new planning is produced by computing in the remaining area by the genetic algorithm with random operation [6], [9].

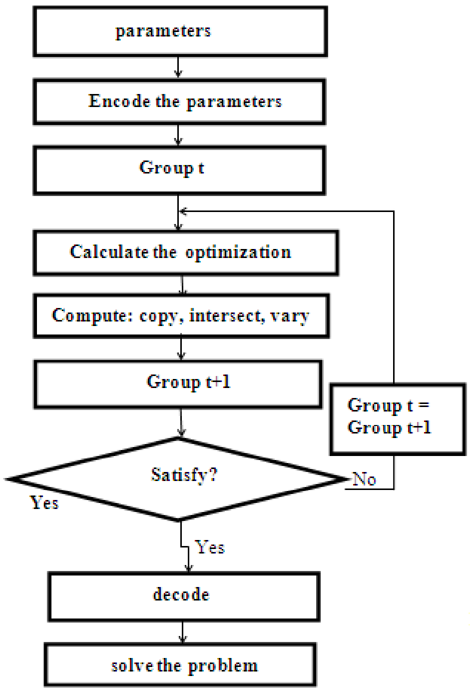

Figure 1. Genetic algorithm flow

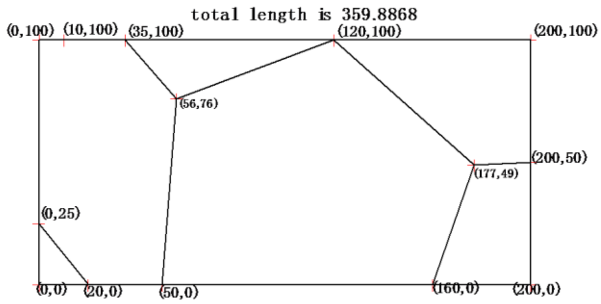

Figure 2. The optimal planning when there are 2 nodes

After producing random numbers in the area for thousands of times during the genetic algorithm, a new optimal planning with minimum total length of roads is mapped in the MATLAB (see in the Fig. 3). The total length of the roads is 371.88m, which can be seen in the Fig. 3.

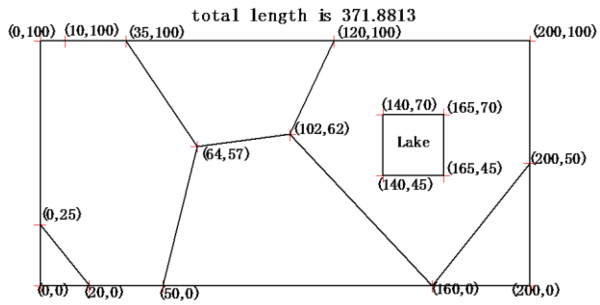

Figure 3. The optimal planning when there is a "lake"

V. Analysis of the Results

According to the six kinds of results, I use the EXCEL to make a line chart for analyzing the optimal planning of the resort roads with the number of nodes in the resort (see in Fig. 4).

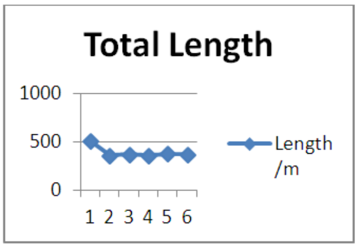

Figure 4. Total length with different number of nodes

From Fig. 4, the total length of the roads in the resort is biggest when the result has one node in it, and the lengths of roads in 6 cases of nodes are almost stable with very small fluctuation. That is to say, if the node is no less than 2, the total length can satisfy the planning target. It can also read that when the number of nodes is two, the total length is the minimum, which is 360m like what I said previously.

VI. Strengths and Weaknesses

1. Genetic algorithm is based on the self-adapting and enlightening so that it has a good convergence.
2. High accuracy of computing and robustness.
3. It takes long time to get the results, take this problem in optimal roads planning as an example, it costs 2 minutes to get the results.
4. Genetic algorithm cannot solve some big and complicated optimal problems, for it can fall into the "early maturing".

Appendix

The other 5 planning when the numbers of nodes are 1, 3, 4, 5, 6 are showed here.

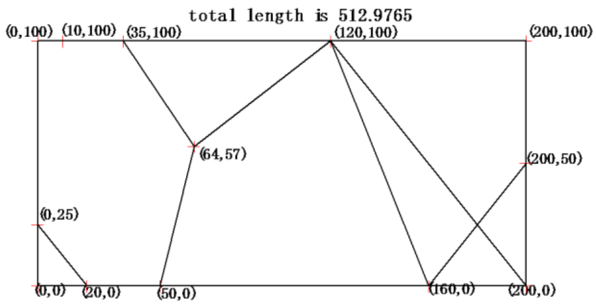

Figure 5. The optimal planning when there is 1 node

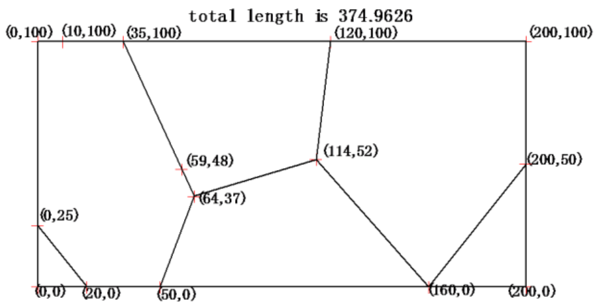

Figure 6. The optimal planning when there are 3 nodes

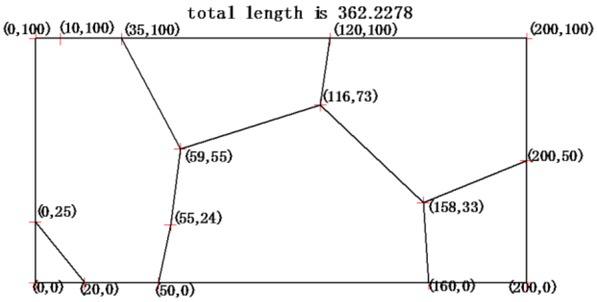

Figure 7. The optimal planning when there are 4 nodes

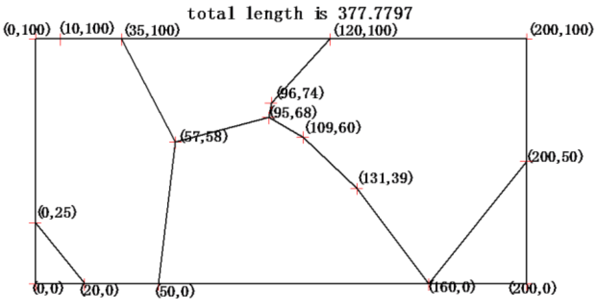

Figure 8. The optimal planning when there are 5 nodes

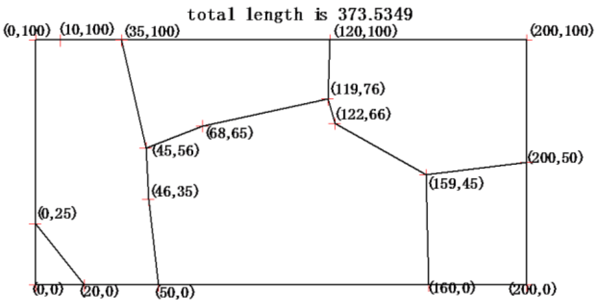

Figure 9. The optimal planning when there are 6 nodes

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