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Research Article

Research on the Food Logistic Optimal Path Planning Method of Improving the Genetic Algorithm

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Abstract: The traditional genetic algorithm randomly selects nodes in two chromosomes for crossover operation, which may result in individuals of disconnected or loop circuit and lead to issues as meaningless crossover operations. In order to increase the diversity of the population and prevent the occurrence of premature mutation algorithm which might cause local convergence, this essay presents a new food logistic optimal path planning method. Initialized from the improvement of population genetic algorithm, it designs the fitness function and optimizes crossover and mutation operators so that the optimal or near-optimal solution can be quickly figured out. Moreover, the Matlab software simulation test exhibits the feasibility and effectiveness of the method.

Keywords: Food logistic, genetic algorithm, path planning

INTRODUCTION

With the development of information technology, route optimization techniques are used more and more in all aspects, such as task distribution, targeting and etc. The most widely used food logistic optimal path planning methods are: parsing algorithm represented by Dijkstra's algorithm and heuristic algorithm represented by the A* algorithm (Zhong *et al*., 2013; Shi, 2010). Although Dijkstra algorithm can get the food logistic optimal path, it's a traversal one with relatively slow solving process. While the A* algorithm, which has faster process, often cannot obtain the food logistic optimal path (Zhang, 2010) due to the difficult choice of an appropriate heuristic. Considering the genetic algorithms' powerful search capabilities, the essay designs an food logistic optimal path planning method based on genetic algorithms.

MATERIALS AND METHODS

The food logistic optimal path design based on genetic algorithms: Genetic algorithms are based on biological inheritance mechanism and the rule of survival. Through crossover and mutation operation on the solution of the parental solution domain, the filial solution domain will then be generated. The poor solutions in the parental solution domain will be replaced by better solutions in the filial solution domain. Repeat this process over and over until the optimal solution or approximate optimal solution (Zhang *et al*., 2012) could be obtained.

Traditional genetic algorithms are generally divided into nine steps, which are: network diagram, chromosome coding, population initialization, fitness function design, selective operation, crossover operation, mutation operation, reinsertion and genetic algorithm termination conditions (Wang *et al*., 2013). The essay mainly focuses on population initialization, fitness function design, crossover and mutation operations. The flow chart of the path planning is shown as in Fig. 1.

Population initialization: If an individual of the initial population indicates an disconnected circuit, which means there is no path between two adjacent nodes, it then has not practical meaning. And if an individual of the initial population indicates a loop circuit, represented, then it's quality would be questionable. Therefore, when the population is initialized, such kind of individuals must be avoided (Madhavan *et al*., 2010).

Methods to avoid individuals of disconnected circuit in generating the initial population of chromosomes are as follow. Choose the starting point of the chromosome as the first node and then randomly selected one from the road that directly connected to the starting point as the second. Choose the third node from the road that's directly connected to the second. Repeated this process till the node as the end of the chromosome has been selected. At this point, if the node number of chromosomes hasn't reached to the chromosome's length n, fill in the rest with 0 after the node representing mobility. If the number of nodes has reached to the chromosome length n, but the node

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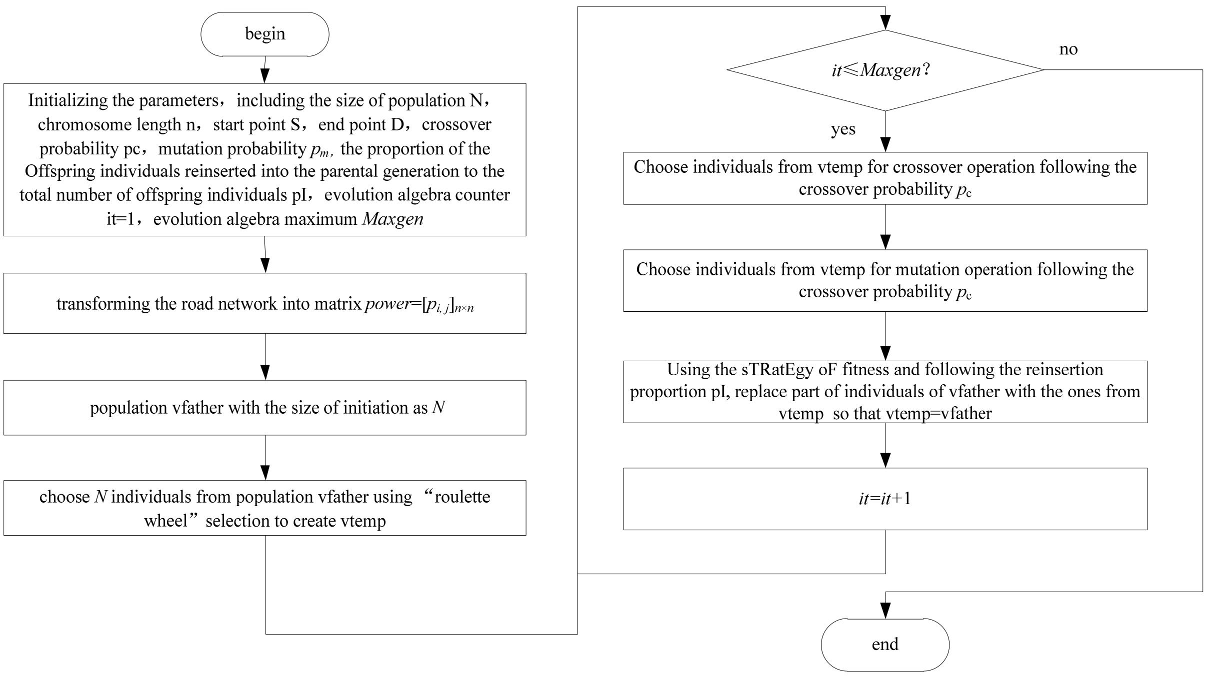

Fig. 1: Motorized path planning process

representing mobility isn't the last node of chromosome, then it should be set as so. Disconnected circuit might exist in the last to nodes of such chromosome, but it can be eliminated through subsequent evolution. Methods to avoid loop circuit in the previous process are as follow: Mark every node which has been identified as the node of the chromosome and choose other nodes only from unmarked path. Remove all the marked nodes along paths after an individual is generated. Then follow the same method to generate new individuals. Ultimately, an initial population *vfather* with *N* individuals would be created.

Fitness function design: Fitness is a parameter used to evaluate the quality of an individual. In general, the better the quality of an individual is, the greater is its fitness. The fitness function the essay designs is:

$$f_i=(n-1)\times \max\{p_{x,y},\ \ x,\ y=1,2,\ldots,n\}-\sum_{j=1}^{d_i-1} p_{g_i(j),\,g_i(j+1)} \quad (1)$$

In the function, represents the fitness of the chromosome; represents the length of the chromosome; represents the maximum of the elements in the matrix; represents the node on the chromosome; represents the position number of the corresponding node to the maneuvering end of the chromosome on the chromosome. As shown in the fitness function, the longer is the time-consuming path of the chromosome, the smaller the fitness would be. It also ensures that all the fitness of the chromosomes is non-negative.

Improved crossover operator: Crossover operation includes selecting two chromosomes as the parents, exchanging part of the gene segments between the two and then creating two new filial chromosomes (Yan *et al*., 2010). As we all know, the traditional crossover operation as randomly selecting nodes from two chromosomes might result in individuals of open or loop circuit, which would lose the meaning of the operation. To avoid such possibilities, improvements to the old operation are as follow.

Step 1: First, generate a random matrix C with N rows and 1 line. Element $C_{i,\,j}$ of matrix C is a random number among 0 to 1. Then, compare it to the crossover probability P_c. If $C_{i,\,j} \leq P_c$, $C_{i,\,j} = 1$; $C_{i,\,j} = 0$ if otherwise.

Step 2: Identify the lines where $C_{i,j} = 1$ and corresponding chromosomes in the matrix vtemp. Match every two neighboring chromosomes as a pair of parents. Make sure that each chromosome can only appear in one pair of parents. If the total number of chromosomes is odd, then the last one chromosome should be discarded, which means it should not be used as one side of any parents.

Step 3: As inside the parental chromosomes, search for the same nodes besides the starting point S. Go to Step 4 if such nodes exist, otherwise, go to Step 5.

Step 4: Among all the same nodes besides the starting point S inside the parental chromosomes, select front two as a crossing point. Remain the nodes before the crossing point unchanged, while exchange the nodes afterwards. Replace the new two chromosomes after the exchange with the original two in vtemp. Then, go to Step 6.

Step 5: In parental chromosomes, select one with less non-zero nodes. Randomly select a non-zero node and mark the position as the cross point of the parental chromosomes. Remain the nodes before the crossing point unchanged, while exchange the nodes afterwards (including intersections). Replace the new two chromosomes after the exchange with the original two in vtemp.

Step 6: To avoid possible loops generated by the exchange, processing the individuals after the exchange with the methods used in population initialization process to avoid loop circuit individuals. The chromosomes obtained after Step 5 might contain individuals indicate disconnected circuit, but they will be eliminated in the subsequent evolution operations.

Step 7: To determine whether each of the parents chromosomes cross finished and if so, the crossover operation ends, otherwise, go to Step 3.

Improved mutation operator: Mutation operation is the process of creating a new chromosome via mutates selected genes (i.e., chromosome nodes). Therefore, the diversity of the population would be increasing, the search scale of solution would be broadened and then the local convergence caused by premature algorithm could be avoided (Zhou *et al*., 2012). Since conventional random mutation operation may generate filial individuals indicate disconnected or loop circuit, which would lead to invalid operation, the traditional mutation operation has been improved as follow, improved mutation operation is as follows in order to avoid such a situation:

Step 1: First, generate a random matrix C with N lines and 1 row. Each element of the matrix C is a random number among 0-1. Compare to the mutation probability. If, then; otherwise.

Step 2: Identify the lines in the matrix C that. Generate a matrix vtemp through crossover operation. Identify the corresponding chromosomes of these lines and use these chromosomes as the objects of follow-up mutation operation.

Step 3: Choose any node from the second to the last but one inside the selected chromosomes as a variation node. Remain the variation node and the nodes before it unchanged. Then randomly choose the next node from the ones that directly connect to the variation node, the rest to be done in the same manner, until the maneuver node is selected as the next node of the chromosome. At this point, if the number of chromosomes hasn't reached to the chromosome length n, then fill in the rest nodes after the maneuver node with 0. If the number of nodes that has been identified has reached to the chromosome length n, but the maneuver node isn't selected as the last node in the chromosome, then the last node of the chromosome should be set as the maneuver node. The chromosomes thus obtained through this process may still contains individuals indicating disconnected or loop circuit, but they will be gradually eliminated in the subsequent evolution operations.

RESULTS AND DISCUSSION

Here is an example of applying the designed genetic algorithm to planning a motorized path. The road network is shown in Fig. 2. Number 1, 2, 3... 16 are the nodes of road. The number attached to a connection line indicates the time consumption (minutes) that single equipment needed to pass through this section of the road. If the single equipment starts off at 1 and finishes at 16, which path is the shortest one?

According to Fig. 2, the road network can be illustrated as the following matrix:

$$power=\begin{bmatrix}
0 & 4.2 & 3.4 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100\\
4.2 & 0 & 100 & 4.4 & 4.1 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100\\
3.4 & 100 & 0 & 100 & 5.6 & 3.5 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100\\
100 & 4.4 & 100 & 0 & 100 & 100 & 2.9 & 3.5 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100\\
100 & 4.1 & 5.6 & 100 & 0 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100\\
100 & 100 & 3.5 & 100 & 100 & 0 & 100 & 100 & 5 & 4 & 100 & 100 & 100 & 100 & 100 & 100\\
100 & 100 & 100 & 2.9 & 100 & 100 & 0 & 100 & 100 & 100 & 3.2 & 100 & 100 & 100 & 100 & 100\\
100 & 100 & 100 & 3.5 & 2 & 100 & 100 & 0 & 100 & 100 & 3.2 & 3.4 & 100 & 100 & 100 & 100\\
100 & 100 & 100 & 100 & 2.9 & 5 & 100 & 100 & 0 & 100 & 100 & 3 & 4.2 & 100 & 100 & 100\\
100 & 100 & 100 & 100 & 100 & 4 & 100 & 100 & 100 & 0 & 100 & 100 & 2.2 & 100 & 100 & 100\\
100 & 100 & 100 & 100 & 100 & 100 & 3.2 & 3.2 & 100 & 100 & 0 & 100 & 100 & 4.5 & 100 & 100\\
100 & 100 & 100 & 100 & 100 & 100 & 100 & 3.4 & 3 & 100 & 100 & 0 & 100 & 2.2 & 4.2 & 100\\
100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 4.2 & 2.2 & 100 & 100 & 0 & 100 & 3 & 100\\
100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 4.5 & 2.2 & 100 & 0 & 100 & 2.8\\
100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 4.2 & 3 & 100 & 0 & 2.2\\
100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 & 2.8 & 2.2 & 0
\end{bmatrix}$$

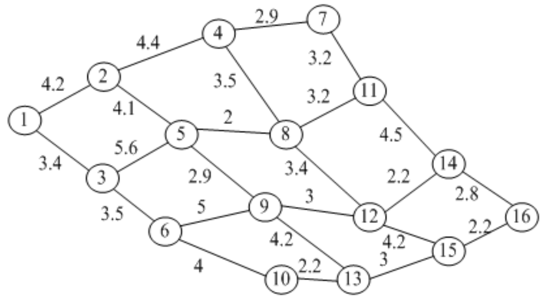

Fig. 2: Road network

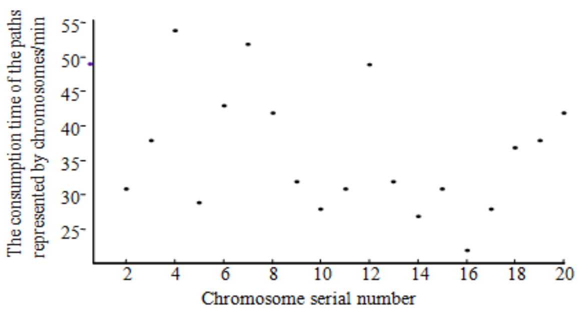

Fig. 3a: Consumption time of the paths represented by the chromosomes of the initial population

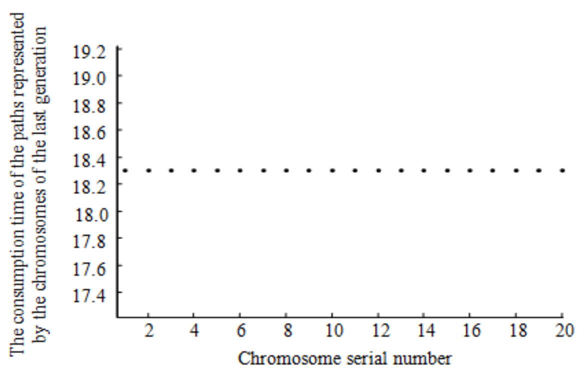

Fig. 3b: The consumption time of the paths represented by the chromosomes of the last generation

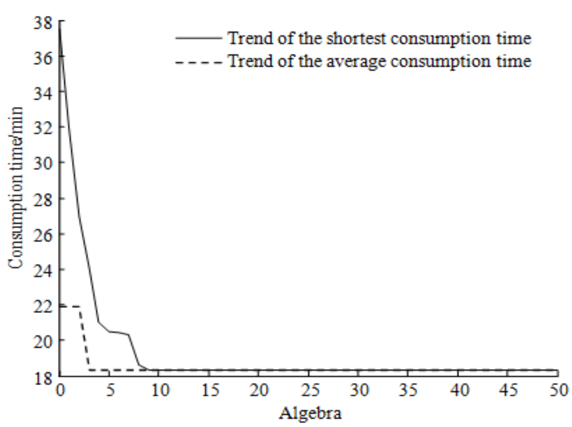

Fig. 3c: The trend of the shortest consumption time and the average consumption time in each generation

Set the size of the population, chromosome length $n = 16$, the start point $S = 1$, the end $D = 16$, crossover probability, mutation probability, the proportion of the filial individuals reinserted into the parental generation to the total number of filial individuals, the maximum algebra of evolution. The results run by the designed genetic algorithm program are shown in Fig. 3.

Information source system: The essence of information source system is Fig. 3a illustrates the time consumption of each chromosome in the initial population represented, which is somewhere between 20~55 min. Apparently the qualities of the chromosomes of the initial population are inconsistent. Figure 3b exhibits that among the last generation the consumption time represented by each chromosome are all 18.3 min, which proves that the last generation has reached a better degree of convergence. Figure 3c shows the trend of the shortest consumption time and the average consumption time in each generation throughout the whole evolution. The food logistic optimal path has been obtained at about the third generation and at about the ninth generation all individuals converge to the optimum. The food logistic optimal path obtained eventually through the program, from the starting point S = 1 to the end D = 16, is 1→3→6→10→13→15→16. The total consumption time of the path is 18.3 min. The results of the program prove the effectiveness of the designed using genetic algorithms on planning the maneuvering path.

CONCLUSION

Targeting the problems existing in current food logistic optimal path planning algorithm, the essay raises food logistic optimal path planning method based on improved genetic algorithm and uses the Matlab simulation software to examine its validation. This method solves the problems of disconnected and loop circuits which may easily occur when genetic algorithm is applied to planning food logistic optimal path. The experimental results show that the improved algorithm can quickly get the solution of food logistic optimal path planning, but there is no in-depth research conducted regarding the reasonable quantification of road environment information and traffic conditions, which will be the next step of the study.

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