

A Bus Transfer Optimization Model Based on Genetic Algorithm*

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Abstract In order to facilitate public transport, the passenger to make the right decisions on the bus selection, in this we have proposed a transfer optimize model, starting from the transport network proposed the possible shortest time model, and realize it through genetic algorithm. The results show that genetic algorithm can effectively deal with bus transfer path-objective optimization problem. The genetic algorithm in the optimization decision-making of actual public transport is to get more and more widely used.

Key words Traffic network; Genetic algorithm; Tool selection; Urban transportation

1 Introduction

Bus transfer problem has been researched in some algorithms currently, for example: Ruichun He(2004), Zhen Hu(2007), Huayu Deng(2008)^{[1][2][3]} and others, they use of improved labeling algorithm, the breadth-first search algorithm and the improved Dijkstra matrix algorithm, are obtained optimal route between any two stops. In this article, we hope to explore the genetic algorithm in the application of transfer buses, to get the optimal transfer programs. Lanfen Liu and Xiaoyu Ni (2005)^[4] successfully use of genetic algorithms to solve the problem of railway passengers to transfer, give us great inspiration. Guoqing Yu (2007) and Guoliang Chen (2001)^{[5][6]} had apply genetic algorithm for bus transfer a good foundation; it is realization of the model has helped.

Nowadays city buses are an important basic infrastructure for urban life. Is a key factor in the success of urban transportation, is one of the dominant urban public transport system. In order to facilitate passengers to make the right decisions on the bus selection, we propose an optimized model, starting from the transport network, propose the shortest possible time model, and then using a genetic algorithm realize it. The results show that the model and algorithm can achieve a satisfactory solution.

2 Bus Transfer Problems

With the continuous development of cities, How to provide good public transport transfer programs, which became a subject of public transport services. This paper is based on the analysis of the actual situation of public transport, which leads to realistic bus transport transfer algorithm, and implement the algorithm.

2.1 Factors influencing transfer of passengers

Passenger transfer, select the tools are often subject to several factors, the role of^[2]: (a) transfer times; (b) Trip distance; (c) The travel time-consuming; (d) travel costs. In the present rapid economic development, it is accelerating the pace of life circumstances, most people prefer a shorter distance, time shorter way to travel. So in this article we will consider time factor shorter way to travel, with time as the objective function.

2.2 Building transfer network on the bus lines

Transfer network of public transport passengers can choose to bus departure station, destination, and stops as a network node. If the road network is based on the road network diagrams, then we can directly assign all the bus information to any sites. then get the right network is a multi-network. Build out the network based on the transfer bus lines. Bus stop as a site, on the same route adjacent bus stops, along the bus direction connecting stops with arc, said the two adjacent bus stops^[4].

Set $G = (N, A, T)$ as a directed graph. Where $N = (1, 2, \dots, n)$ is a set of nodes from the station constituted; $A = \{a_{ij} \mid i, j \in N, i \neq j\}$ is the arc set, said the link of the stops; $T = \{t^k(i, j) \mid i, j \in N\}$ is the parameter value of each node; $t^k(i, j)$ that the time spent on no.k bus from i to j stop. $k \in N_u, N_u$ is all

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set to bus lines.

From the practical need to considering switch the request of the shortest distance to the total travel time to a minimum. Total travel time is consists of two parts: travel time (including bus stops time), and the transfer waiting time. Transfer time is the required buses waiting time simplified as a constant, with t_0 said. The transfer times no more than a constant (usually three), with C said.

3 Transfer Mathematical Model

Construction of mathematical model :

$$\text{Min } Z = \sum_i \sum_j \sum_k t^k(i, j) x_{ij}^k + \sum_i \sum_j \sum_m \sum_k T_0 x_{ij}^{k_1} x_{jm}^{k_2}$$

$$\left\{ \begin{array}{l} 1 \quad \text{no.k bus can reach j from i stop} \\ x_{ij}^k = 0 \quad \text{others} \\ \sum_j \sum_i x_{ij}^k = 1 \quad (1) \\ \sum_j \sum_k x_{jm}^k - \sum_j \sum_k x_{mj}^k = 0 \quad m \neq s, n; \forall m \in N \quad (2) \\ \text{s.t.} \quad \sum_i \sum_k x_{im}^k = 1 \quad (3) \\ \sum_i \sum_j \sum_k x_{ij}^k \leq C \quad (4) \\ Z \leq T \quad (5) \\ x_{ij}^k, x_{jm}^k \in \{0, 1\} \quad \forall (i, j), (j, m) \in A \quad (6) \end{array} \right.$$

In which the first part of the objective function expressed the travel time used by no.k bus to the j stop from i, with $t^k(i, j)$ said. The second part said transfer time at j stop when from i stop by bus k_1 via j stop Transfer bus k_2 arrives at m station, Simplified to a constant t_0 .

The constraints(1)ensure that from the source node has a path ,constraint (2) is a balance constraints condition of each node; Constraint (3) ensure that there are paths to reach the end point n; Constraint (4) makes the transfer times do not exceed C; (6) is the total travel time T constraints, and urban public transport generally set according to the size of cities, this article set $T = 2h * 60\text{min}$; Constraint (5) ensure that 0, 1 variable values. Constraint conditions (1)–(3) is the overall assurance from the source point to the end there is a path. This paper has constructed a mathematical model which’s objective function is non-linear function, is a kind of constraint and complex issue of the minimum travel time and can not find the exact solutions in the traditional algorithms. Therefore, we use genetic algorithms to find the optimal solution.

4 Genetic Algorithms

By using genetic algorithms to solve shortest path problem we must first encoding the path in the map, characterized by the path that contains the number of nodes is not fixed. Do not reject each generation of the infeasible solutions. It is appear in the mathematical model that transfer times and transfer times inequality constraints, with the constraint transfer times constructing the penalty function, using feasible solution to increase the value of the goal on behalf of the ways to reduce their fitness, and retain a certain number of infeasible solutions.

When the transfer does not meet $\sum_i \sum_j \sum_k x_{ij}^k \leq C$ constraints, with the degree does not meet the minimum transfer times as the penalty function coefficient, with α said. Set $c = \frac{\sum_i \sum_j \sum_k x_{ij}^k}{C}$, $\alpha = C / c$ punish parameters, taking into account the number of infeasible solutions.

Then the objective function is: $f = Z + \alpha \sum_{i=1}^{pop_size} P_i$

Which : Z is a mathematical model to represent the total travel time of expression;

$$\alpha = \begin{cases} M\alpha & unm > pop_size/2 \\ \alpha & \text{Others} \end{cases}$$

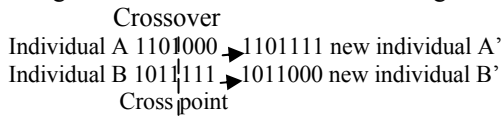
M said a large number; unm is the number of infeasible solutions; pop_size is the size of population; $P_i = \max(0, C - c)$, $1 \leq i \leq pop_size$.

4.1 Chromosome structure

Gray code has the advantage of two consecutive integers between the values corresponding to the coding is only one code points are not the same, the remaining code points are identical, for example: 15 and 16 of Gray code is represented as 01000 and 11000. Using the Gray code encoding method^[5] will help improve local search ability of genetic algorithms; Crossover and mutation operation is easy to realize; is consistent with the principle of the minimum character set; easy to use schema theorem theoretical analysis of the algorithm.

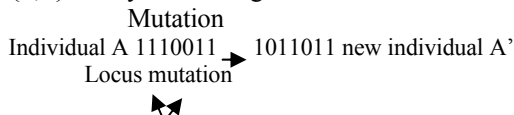
4.2 Crossover and mutation

This paper we use a simple cross. To do is^[6]: set a random cross-point in the string of individual, the implementation of cross, swap part of the structure before or after that point of the two individuals, and generate two new individuals. Here gives a simple cross-example.



Pairs of chromosomes are going to be tested. First exam chromosomes after cross that it means one path. If the new chromosome's objective function value is infinity, then this new chromosome are not from the source to destination node of the path; otherwise, is from the source to destination node of the path. In addition, exam whether the chromosomes after cross is consistent with the minimum times. The minimum transfer times with the chromosome test function to test new chromosome is feasible.

The basic mutation operator means: the group of individuals in code string, random selection of one or more loci, and make changes in the gene value (make changes with the mutation probability P_m), {0,1} binary code string of The basic mutation operation is as follows:



From the chromosome that going to mutation operation randomly generated one or more variation points, select the mutation points change 0 to 1, 1 to 0. Then we get a new chromosome. First check whether the mutation of chromosome is from the source node to destination node of the path, if it isn't then randomly generated another variation, when it is a path then test the transfer times constraints of the chromosome. When the chromosome is not feasible, then randomly generates another mutation point, and further mutation.

4.2 Fitness function

The objective function with improved fitness functions as the

original: $f_i = Z + \alpha \sum_{i=1}^{pop_size} P_i$, since the objective function to be seeking minimum, will be

deformation of the fitness function $f'_i = M - f_i$, M represents a large number. Evaluation function as follow :

$$Eval(V_i) = f'_i / \sum_{i=1}^{pop_size} f'_i \quad i=1,2,\dots, pop_size$$

Use Roulette methods choice of genetic operator to be a new species; with a fixed number of cycles control the end of genetic algorithms.

5 Experiments

Figure 5.1 intends to seek a city bus system model, from the 2 station to reach no.29 station for the least of total travel time and the least transfer times of the travel programs.

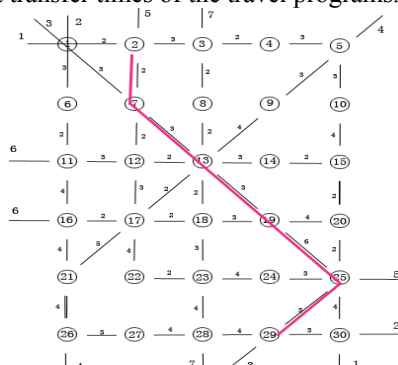


Figure 1 Experiment of A Bus Transfer Optimization Route Based on Genetic Algorithm

Examples are not large in scale, so the size of population is 90, crossover probability $P_c = 0.6$; mutation probability $P_m = 0.1$, $t_0 = 2min$, with the number of control loop end of the process, recycling 1000 times the results obtained are getting There: From the 2 station by bus 5 to reach 7 station, transfer from the 7 Station by bus 3 to reach the terminal 29 station, transit 1 times. The total travel time is at the least 21min. than we obtained the transfer program that the least of total travel time and the least transfer times 1 times which program from no.2 station to reach no.29 station.

6 Conclusions

From the above steps for solving the modeling process and model analysis, we known that genetic algorithm can effectively deal with bus transfer path-objective optimization problem. The genetic algorithm in the optimization decision-making of actual public transport is to get more and more widely used.

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