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Improved Genetic-Tabu Search Algorithm in Bus Scheduling Study

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Abstract—Because the existence of defects in the traditional genetic algorithm,we use the improved the genetic-Tabu Search algorithm(GA-TS) in this paper for the optimization of bus scheduling model,then got over the traditional genetic algorithm's problem such as slow-evolution,premature,local optimal solution and other issues,simulation results show that:GA-TS optimize performance superior to the traditional genetic algorithm.

Keywords-public transit;genetic algorithm;Tabu Search algorithm;Improved genetic-Tabu Search algorithm;

1. Foreword

The core business of bus company's is to provide operational services to the public,as the bus company's resources for operational is limited,therefore,use it reasonable and efficient to meet the public's travel needs with maximize available resources,which is critical to bus company and can bring hug cost savings too.That is why the public transport scheduling problem being widely attention and research.This article said the bus scheduling problem for the planning problem in order to distinguish with the site dispatching problem.Bus scheduling problem is the core content of the city bus transport dispatch,which is also the basic reference for bus operation personnel,the driver and the steward to work together and whether the normal operation of the bus.The genetic algorithm has been success applied in many practical application and optimization problem[1][2],but it has the problems such as simple,slow-evolution and esay get a local optimum,and then lead to convergence in advance.Based on the above-mentioned,this article combined another search method—Tabu Search algorithm(TS) with GA to form the improved genetic Tabu Search algorithm(GA-TS)[3].Then avoid being trapped in local optimum,and overcome the defect of premature for traditional GA,and improve the efficiency of optimization.

2. Bus Scheduling Optimization Algorithm description

2.1. The improved genetic algorithm

The genetic algorithm(GA) is a calculation model by simulating Darwinian's natural selection of biological evolutionism and Biological evolution process of genetics mechanism,which is a optimization

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method by simulating natural evolution process to search the optimal solution, Holland,the professor at the Michigan university in United States,first put forward the concept of genetic algorithm, and the main features of genetic algorithm are:group search strategy and the information interaction between individual.It is no specific genetic rules,but using probability change rules to guide the search direction,therefore it possesses higher robustness,apts to optimize,and thus its application scope is quite broad.It is a new kind of global optimization algorithm of search.In this work we make improvements as follows:

- We adopted real value coding method can avoid code and decode.
- Choice method by Roulette method optimal reserved strategy is used.
- Both of double and single-point crossover operation is used.

2.2. The Tabu Search algorithm

Tabu Search algorithm is a meta-heuristic random search algorithm,it is starting from an initial feasible solution, choose the search direction as a number of specific test, choose to achieve a specific objective function value to changes in the most mobile.To avoid falling into local optimal solution,TS search through the establishment of a tabu Tabu list,it uses a flexible "memory" technology,record and choose optimization process which has been carried out to guide the next step of the search direction,tabu search allows acceptance of inferior solutions in the search process,which makes the tabu search algorithm has a strong "mountain climbing" ability to jump out of local optimal solution[4],and then turn to search other areas,thereby greatly increasing the probability of access to better solution or global optimal one.

However,tabu search is dependent on the initial value in large degree,a good initial value can search for a satisfactory solution,while the poor one would reduce the speed of convergence,and the quality of solution obtained is not high.

Tabu search algorithm can be described as follows:

1) Given algorithm parameters,generated initial solution x randomly,set tabu table empty.
2) Judge the algorithm whether meet to the end conditions?If so,then end the optimization algorithm and output the results;otherwise, continue the following steps.
3) Using the neighborhood function of the current Solution to produce its all (or several) neighborhood solutions,and determine a number of candidate solutions from which.
4) Defiance of the norms to judge whether the candidate solutions to meet condition? If true,then use the best condition y which meet the criteria for contempt to replace x as a new current solution,which is x=y,and use the tabu object corresponding with y to replace the first one in the tabu object table,while y replaced "best so far "state, then transferred to step 6;Otherwise, continue the following steps.
5) Judge the candidate solution corresponding to the object of tabu properties,select non-tabou objects in candidate solution correspond to the best solution as the new current solution,use the object corresponding replace the object element which enter into the tabu table first at the same time.
6) Transfer to step (2)

2.3. The improved genetic-Tabu Search algorithm

In view of both of the genetic algorithm and tabu search algorithm have Inevitable shortcomings,this paper adopt two algorithms proposed by literature[5] witch based on a combination of strategies to solve the bus scheduling problem,that is to say use tabu search as the genetic algorithm’s variation operator,here in after referred to as tabu mutation operator,each of individual independent optimization before reproduction.This strategy will make tabu search algorithm embedded in the genetic algorithm (as shown).Using tabu search algorithm’s strong climbing ability to avoid the "premature" phenomenon exist in genetic algorithm effectively.Meanwhile,use genetic algorithm to get initial solution to improve the solution quality.The main flow chart of the improved genetic-tabu search method is as follows:

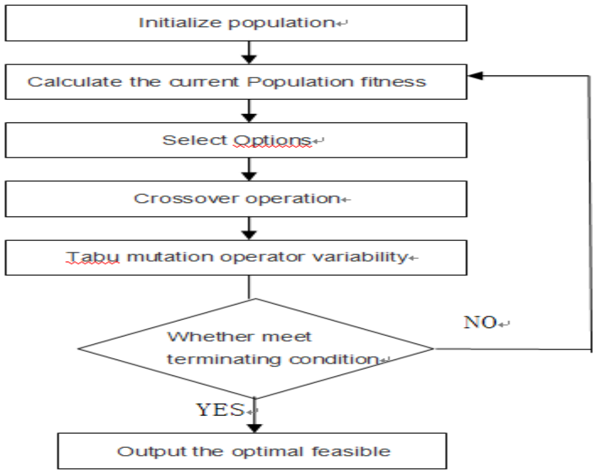

Fig.1 The flow chart of GA-TS Algorithm .

3. Description of Bus Scheduling Problem and establishing mathematical model

Bus scheduling is the prerequisite and basis for bus dispatch,arrange transport vehicles reasonable to run operations,in order to achieve supply-demand balance,this is a multiobjective optimization problems,this article will introduce the improved GA-TS which proposed previously to optimize driving plans.

3.1. Description of Bus Scheduling Problem

The purpose of public scheduling is to determine the scheduling operation of optimal or approximate optimal.According to this scheduling table,public busteam can achieve supply-demand balance.This project select lanzhou NO.139 bus as scheduling object representatively,only considerate downlink lines and take autumn,winter for example,and optimizing its driving schedule.This line has 16 stations,first-run bus start at am 6:40,last-run bus end at pm 8:30.All operation bus depart in the whole minutes,regarding the intervals time distenced the first as time of departure.The time of departure is selected as decision variables,the unit is minutes,the total number is m within a day,830 minutes for the total time,i.e. x1, x2,…,xm.Where x1 is defined as first-run moments corresponding to am 6:40,and xm is defined as last-run moments(the 890th minites) corresponding to 20:30,i.e. decision variable meet the condition:x1+x2 +⋯+xm=830. The passenger flow volume in the whole day is given.the goal is to arrange transport vehicles reasonable to run operations,in order to achieve supply-demand balance,meet the performance of system.

Due to it would be influenced by vast number of scheduling rules,it is necessary to make the following simplifications and assumptions for the problem of public busscheduling:

a) The type of bus vehicle is identical;
b) Bus start in sequence,no queue-jumping phenomenon;
c) Within the same time,the adjacent departure time interval equal to two buses;
d) Bus get in or outstation on time according to schedule time,no stranded passengers,bus maintain uniform traffic;
e) Bus start orderly and in queue;
f) Time delay caused by the traffic lights is equal in the same time-interval;
g) Regard minute as the smallest unit of time;

3.2. Establish mathematical model

Bus dispatching Problem is that in the fixed running line, according to different times and some first order relations, rationally arrange of transport vehicles to run operations to achieve a balance of supply and demand to meet the system performance,I.e. the objective function.This performance index used here in this paper is: in the flat peak or peak hours, buses run according to fixed, so that the shortest turnaround time transport vehicle operating is used as a performance index And try not to delay,to avoid "string car" or "Spaced",Therefore to add penalty terms for the the extended delaying vehicles in the performance index.Vehicles should also be run to meet the constraint relationship of the first order,so the definition of the objective function:

$$\min T_0 = \sum_{i\in M} \max T_t + \omega \sum_{j\in N} \max(0, t_{sj} - t_{rj}) \tag{1}$$

where T0 is transport vehicle turnaround time that is from the desparting of the first bus to the returning of the bus k;Tt is the running quota time of bus i completing the transportation task,i.e. the bustime from the starting point to the end; tsj,trj denotes the service time(stop time)of reaching the station j and regulated service time respectively; ω is Penalty term weighting c,where we take the appropriate penalty coefficient according to different buses operating hours,for example,in the flat peak hours the penalty term is randomly generated of the normal distribution,the fixed coefficient is used in the peak hours.

3.3. The Fitness function

Set the fitness function according to the target function. Objective function of bus scheduling model is the minimized problem.In order to guarantee the fitness of chromosomes not be negative values,the fitness function is adopted as follows:

$$F(X) = \mathrm{E}_{\max} - f(X) \tag{2}$$

where f(x) denotes the objective function for the individual, $\mathrm{E}_{\max}$ is the maximum value of all the objective function in same generation,so the value of fitness function f(x)>=0,and the bigger value of objective function,the smaller the fitness.

3.4. Initialization population and Coding

Combined with the characteristics of public busscheduling,this paper apply real-value coding method [6].In this method,the value of individual chromosome in each loci is the real-value of decision variables,which can avod the complicated coding and decoding process,Corresponding to $X = [x_1, x_2, ..., x_m]^T$ the X chromosome denotes code strings $[x_1, x_2, ..., x_m]$,The length of the genetic code is the number of decision variables i.e.m,after applying real value coding,the value at every code position (loci)is regard as the time of distence from the start time,units is minutes,where the first starting time is defined as 0 minute,such as the coding string with length for (0,6, 16,⋯,830),0 denotes first-runtime at 6:40 am,8 indicates the second bus start from starting time namely six minutes 6:48 am,⋯,830 denotes 830 minutes from starting time namely 8:30 pm.

3.5. Initialization of population

Initialization of population namely random generate initial chromosomes to constitute population,initialization must meet the first and last run time in rules.

4. Design the operator of genetic algorithm

General speaking,genetic operator include chosing,crossing and mutating operators,witch acts on group P(t),and then creates a new group P(t+1) of generation.

4.1 Selection operator

We use the proportion selection method and optimal reserved strategy in this article,optimal reserved strategy is used in public bus scheduling,which can ensure the optimal individuals not to be destroyed by the genetic operations such as crossing,mutating and so on,and go straight towards the next generation.it can be seen clearly that this method has a stronger ability of searching for the best.

4.2 Crossover operator

We choose dynamic one piont crossover[7] as the crossing operation of GA.The process of crossing is shown as follows:

Selected a chromosome from the population according to crossover probability PC,select a breakpoint in the chromosome randomly, exchange he right end of the breakpoints in Parents to generate a new offspring.In this article, the individual must meet the conditions of the late-start time for using the real coding.Although the selection of intersection is random,but there may have someone never satisfied conditions after crossing,in this situation,we choose to re-re-cross the intersection,however, in some cases, there may never meet the conditions,we will the let genetic from parent direct to offspring.

4.3 Mutation operator

Using tabu Mutation operator role in an individual,it is an independent optimization for the individual itself In fact.As the embedding of the tabu mutation operator, the climbing ability of the algorithm enhanced,then avoid the "premature" phenomenon effectively.

5. The Simulation and Analysis with Improved Genetic-tabu Search Algorithm to Optimize bus Scheduling

Combining GA with TS can learn from each other and give play to their respective advantages,which can make up for some deficiencies of the single optimization method . TS is introduced into GA,so that TS is adopted to do the optimization process independently for each individual of the population,during the "nurturing process",And then using mutation operations to get the better population characteristics,thus achieving the optimal evolution. To verify the effectiveness of the GA-TS algorithm to optimize transit vehicle scheduling problem,GA-TS algorithm is used here and compared with a simple GA.Directing at the scheduling problem of Lanzhou NO.139 bus for of separate operation optimization problem solving is done respectively.

The determination of experimental basic parameters:To make sure the genetic algorithm parameters such as the crossover probability,mutation probability,evolution algebra and so on,we make a large number of experiments. Finally the parameters of the better performance are obtained as follows:Let crossover probability Pc be 0.92,mutation probability Pm be 0.0001,population size be 100,genetic algebra be 400:

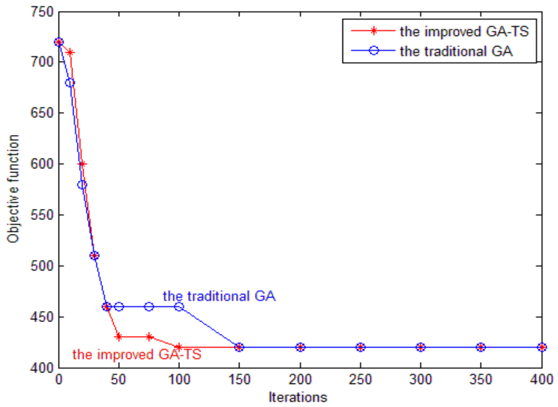

Fig.2. Comparison of Convergence rate based on traditional GA and the improved GA-TS

The convergence speed and optimizing quality of both GA-TS hybrid algorithm and the simple GA can be seen from the simulation results as shown figure 1 obviously.GA-TS hybrid algorithm converges very fast,especially when the number of iteration steps increases.The HGA shows better directionality than the simple GA,with the characteristics of strong convergence,good search area and quick moving direction.And reducing its evolution algebra to avoid the premature convergence phenomena of GA,so the optimization performance of transit vehicle scheduling problem is improved.Therefor in the operation management of the actual vehicle scheduling, dispatching Management can adopt the GA-TS scheduling algorithm optimize that the optimal performance is good and the convergence speed is fast.Then the practical and effective operation scheduling scheme is achieved,and also transit vehicle operating is improved and perfected.

6. Summary and Outlook

In summary,using the improved genetic-tabu search algorithm in bus intelligent scheduling is very effective, It can find near optimal solutions in the a huge search space of scheduling optimization problem reliably,it is an effective way to solve the bus scheduling problems,the improved GA-TS is more efficient than the traditional one.However, the problem has been simplified and the assumptions in the course of this paper's specific operation,there are many unforeseen circumstances do not take into account etc.This part of the theory and methods needed further analysis and research.

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