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Summary of Research on Optimization of Urban Rail Transit Operation Plan

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Abstract

Because of its advantages of fast speed, large capacity, safety, punctuality, high efficiency, energy saving and environmental protection, urban rail transit is of great significance to alleviate urban traffic congestion and reduce urban pollution.The train running plan is the core technology plan in the rail transit organization, and it is also one of the research hotspots.This paper expounds the research and development status of the optimization of the development plan of rail transit at home and abroad, summarizes the experience of the optimization plan of the development bank at home and abroad, and summarizes the research status of the optimization plan of the development bank by referring to a large number of literatures.By summarizing the previous research status, the paper analyzes the lack of research on the urban rail transit project in China.

Keywords

Influenza transmission; logistic population model; SIR model.

1. INTRODUCTION

Due to its advantages of fast speed, large capacity, safety, punctuality, efficiency, energy saving and environmental protection, urban rail transit is of great significance in alleviating urban traffic congestion and reducing urban pollution. In China, with the advancement of urbanization, passenger travel demand is increasingly dispersed, and the congestion phenomenon is endless.Most of the urban rail transit lines have been transformed from a single interchange to an interconnected rail transit network, in which the main line and branch line are interconnected while each can operate independently.

The train operation plan is one of the core contents of the rail transit train transportation organization plan, which generally includes 5 contents, that is, the train routing plan,frequency,halting pattern,fleet size,train mode. The routing plan determines the starting point and ending point of the train operation and the route through;Operating frequency determines the number of vehicles operating in a unit time, and then determines its service capability.The stopping plan determines the stopping method of the train in its passing path, which has an important influence on the service capability and service quality.Marshalling plan determines the length of train marshalling, which also plays a decisive role in service capacity.The type of train determines the speed level of the train, the model, the seat type, etc.Therefore, the development plan fundamentally determines the service level of rail transit. A reasonable development plan is of great significance for alleviating urban congestion and accelerating urban economic construction.

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2. DOMESTIC RESEARCH STATUS

2.1. Transportation organization

Zhang Guobao [1] systematically analyzed, summarized and summarized transportation organization issues such as the development history, main technologies, passenger flow analysis and prediction, transportation plan and system capacity of urban rail transit, and made significant contributions to the establishment of the theoretical system of urban rail transit in China.Liu Jianfeng [2] deeply analyzed the passenger flow data of the rail transit lines of four typical cities in China. By analyzing and summarizing the intensity of passenger flow, cross section passenger flow, transfer passenger flow, passenger flow time distribution and transportation distance of each city, he obtained the distribution characteristics and change rules of passenger flow on the rail transit lines during the network process.It provides a theoretical reference for the optimization of urban rail transit organization in China.Zheng Li [3] and other scholars divided urban rail transit network operation into two types, transfer coordination and resource sharing.From the perspective of resource sharing, various resource sharing modes in the form of reconnection train and train through operation are discussed, and the applicability of network operation is analyzed.From the perspective of passenger flow, Yan Bo [4] analyzed the passenger flow prediction method of rail transit lines and the influence of passenger flow distribution characteristics on the passenger flow transportation organization of urban rail transit, and put forward the optimization idea of train departure interval and train grouping scheme, and finally obtained the optimized scheme through case verification.By combining passenger flow transportation organization, Xu Ruihua [5] analyzed the advantages and disadvantages of different routing schemes from the aspects of transit capacity, platform layout and service level of rail transit lines, and put forward suggestions.

2.2. Train operation plan optimization

Rong Yaping [6] et al. based on the unbalanced distribution of daily passenger flow on urban rail transit lines, aiming at the shortest waiting time for passengers and the lowest operating cost of enterprises, and considering constraints such as the number of trains used and the minimum departure interval, established an optimization model of train operation plan, and then designed relevant algorithms to solve the multi-objective model.Finally, the relevant indicators are analyzed based on practical cases.Wang Yongliang [7] adopted the genetic simulated annealing algorithm to solve the two-layer model of train operation routing plan based on the time-space distribution characteristics of passenger flow and travel demand, aiming at the optimal operation network system, and analyzed the ruin resistance of the routing plan.Zhu Yuting [8] studied various influencing factors during the preparation of train operation plan, then took a single line and the entire operation network as research objects, and took passenger travel efficiency into consideration, established a train operation and routing model, and proposed an optimization method of urban rail transit train operation plan under the network background.Lv Xiaodong [9] analyzed the problem of train routing changes under abnormal conditions, and gradually extended the problem from the optimization of single line routing scheme to the optimization of line network routing scheme, and then verified the established optimization model through the Beijing subway line network.Liu Yang [10] studied the construction and full life cycle of urban rail transit in depth, and then verified the optimization model of train operation plan with the goal of minimizing passenger travel cost and enterprise operating cost through Xi 'an Lintong subway Line.Cheng Xiaoqing [11] deeply studied the selection of urban rail transit vehicles, train formation, train routing scheme and train stopping scheme, and established a train routing scheme comparison model aiming at optimal configuration from this perspective.Chen Yue [12] designed the genetic model-quasi-annealing algorithm to solve the routing scheme model aiming at the shortest total waiting time

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for passengers by comprehensively considering the constraints of train load rate and line passing ability, so as to improve passengers' ride experience and train service level while taking into account the constant interests of the operating enterprises.Wang Yuanyuan [13] et al., taking into account the interests of both passengers and enterprises, built a dual-objective mixed integer nonlinear programming model constrained by train tracking interval time, passenger demand and maximum number of available cargoes, then transformed it into a single-objective model by ideal point method and adopted software Lingo to solve the model.Xu Dejie [14], considering the interests of both passengers and operators, built an optimization model of urban rail transit train operation scheme for large and small intersections. First, linear weighting method and penalty function method were used to transform the two-objective constraint problem into a single-objective unconstrained problem, and then a controlled random search algorithm was designed to solve the above model.

2.3. Y-mode routing optimization

Guo Jianmin [15] and other scholars built an optimization model for the operation plan of urban rail transit under the Y-type route collinear mode, and proposed the operation plan under different organization forms of Y-type collinear, but did not consider passenger transfer.Huang Rong [16] analyzed the passenger flow of urban and suburban rail transit lines, took the operation mode of suburban line and urban line through rail transportation as the research object, and proposed the optimization method of over-rail transportation to maximize the capacity of the entire line.Liang Qiangsheng [17] and other scholars pointed out the difficulties and challenges encountered by Guangzhou Metro Line 3 in the operation process, proposed the principle of route setting and summarized several routing schemes for it. Finally, based on the distribution characteristics of predicted passenger flow on rail transit lines, the most suitable routing scheme was obtained, and the operation effect of the scheme was evaluated.Zhu Tong [18] first analyzed the reasons for the generation of Y-shaped traffic, and then established a multi-objective model with the goal of the lowest passenger satisfaction and enterprise operating cost. Finally, through the verification of Xiamen Metro Line 1, he solved and compared different traffic schemes.Yang Yufang [19] took the miniature network of Beijing Metro Line 8 - Changping Line as an example and solved and optimized the three-objective optimization model of train operation scheme under through-running conditions based on this line through genetic algorithm.Finally, the transfer passenger flow, the average load factor of the train and the load factor of the train in the maximum section of the maximum passenger flow were selected to evaluate the solution results.Zhou Yuan [20] investigated and studied the line situation of Chongqing Metro Line 6, based on its line characteristics and passenger flow characteristics, compared different marshalling schemes and routing schemes from the aspects of train organization, operating cost and service level, and finally put forward reasonable suggestions.Geng Liansong [21] analyzed the advantages of Y-mode routing and the setting conditions of Y-mode routing, built a multi-mode routing optimization model with the goal of minimizing passenger travel cost and enterprise operating cost, and finally solved it by using the genetic-simulated annealing algorithm.When Wang Jiaqi [22] constructed the model for selecting routing schemes, the goal was to minimize the travel cost of passengers and the operating cost of enterprises. However, in this model, passengers on the rail transit line could only take the direct train while they were transferring.

3. FOREIGN RESEARCH STATUS

SzetoWY[23] studied the routing and departure frequency of buses between urban and suburban areas, and adopted improved genetic algorithm to optimize the established dual-objective optimization model aiming at the shortest passenger travel time and the least passenger transfer times.ChangYH[24] et al. built a dual-objective optimization model of high-

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speed railway train routing scheme aiming at the shortest travel time for passengers and the lowest operating cost for enterprises, and converted it into a single-objective optimization model using fuzzy mathematics. Finally, a high-speed railway line in Taiwan was selected to verify the effectiveness of the model.FurthPG[25] used dynamic programming method to study the regional operation scheme, determined the start and end point and departure frequency of regional operation, and proved that this method could reduce the transportation cost by taking a traffic corridor in Boston as an example.StrathmanJG[26] and other scholars studied the strategy of real-time control of regional vehicles, and believed that the selected regional vehicles should be vehicles with fewer passengers and smaller running intervals between the front and rear vehicles.CadarsoL[27] built an optimization model of train operation scheme of urban rail transit line with the lowest comprehensive cost for passengers and operators by combining the constraints of the line's capacity, passenger travel demand and the number of cars used. By selecting a line in Madrid, Spain, as a case line, the validity of the model was verified.SchobelA[28] divided the optimization model of urban rail transit train operation plan into a game model that only considers passenger travel cost, enterprise operation cost and passenger-operator cost. In addition to describing the research results of relevant models, Schobela [28] studied the development direction of this problem.DelleSP[29] and other scholars studied the optimal scheduling model of interzone buses for bus operation with the goal of maximizing the net benefits of passengers and operators, aiming at the elastic demand and inelastic demand of a certain radial bus route, and obtained the optimal bus departure frequency and the choice of its vehicle type.It provides a method for the optimization study of the following inter-district vehicle operation strategy.FiooolePJ[30] et al. considered the variable train formation and built an optimization model of train operation plan based on the arrival and departure time of trains and the predicted passenger flow on the line.TirachiniA et al. [31] built a bus route operation scheme model with the objective of minimizing the comprehensive cost of passengers and operators. Then, they analyzed the sensitivity of the distribution combination of up and down passenger flow of the line, and finally concluded that the operation of small routes under certain passenger flow conditions can reduce the comprehensive cost of passengers and operators.

4. SUMMARY OF RESEARCH STATUS AT HOME AND ABROAD

In the early stage, the train operation plan was mainly based on the passenger flow, and then selected the locomotive routing and formation plan of the line, established the model according to the passenger flow and its characteristic quantity as the basic data, determined the objective function and constraint conditions, and finally obtained the optimal or satisfactory solution of the stopping plan.However, it is a complicated process to make the train operation plan.On the one hand, it is necessary to master the travel rules of passengers, summarize the travel characteristics of passengers, maximize the quality of service, reduce the waiting time of passengers, reduce the transfer as much as possible, and improve the train occupancy rate.On the other hand, it is necessary to consider the rational economic use of transportation capacity, make full use of lines and vehicles, reduce operating costs, and increase transportation revenue.In recent years, on the basis of passenger flow, domestic and foreign researchers have comprehensively considered the factors such as network structure, cost and income, line vehicles, passenger service level, vehicle operation economy and operational organization complexity, and incorporated various influences into the model parameters to conduct more in-depth studies on train operation schemes.

4.1. Transportation organization

Domestic and foreign scholars have carried out a large number of optimization studies on vehicle selection, train grouping scheme, train stopping scheme, train departure interval, train diagram cycle [32] and train operation scheme under the large-and-small-route mode of urban

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rail transit on the basis of predicted passenger flow data or actual passenger flow data, combined with its passenger flow distribution characteristics and line operation characteristics.Thus, the optimization of the passenger flow organization of urban rail transit is realized, but there are few studies on the optimization of various problems under different route combinations.

4.2. Bank plan optimization model

Domestic and foreign researchers focus on relatively single factors and few factors in the early stage of the establishment of the CDB program optimization model in terms of mathematical model research, so they often establish a mixed integer programming model with a single main object, and the scale of actual examples is relatively small.After that, with the network of the track construction line, the multi-objective planning model is established and more factors are added. The model types are mainly multi-objective nonlinear programming and 0-1 programming.As the number of factors of concern increases, the model size increases, and the model algorithm begins to use more intelligent methods, such as fuzzy mathematics, dynamic programming, ideal point method and genetic algorithm.In recent years, the mathematical model research of train operation plan not only focuses on the plan itself, but also combines the passenger flow allocation model and elastic demand model to establish a multi-objective double-layer programming model.For large-scale planning models, heuristic algorithms such as hybrid algorithm, genetic algorithm, particle swarm algorithm, and simulated annealing algorithm were mainly used in model algorithm research, or optimization algorithms based on heuristic algorithm were combined with various algorithm ideas, as shown in Table 1.Although there are many algorithms in the model, the overall idea is divided into two kinds.Variety of complex to simple, multi-objective into a single or double objective optimization.At this time, there are many methods that can be used, such as main objective method, linear weighting method, evaluation function method and so on.One is to stratify the goals, give a sequence of goals according to their importance, and find the optimal solution of the next goal in the solution set composed of the previous optimal solution until a common optimal solution is obtained.Goal programming is a common transformation method.For large-scale programming problems, the heuristic algorithm is a more efficient solution.

5. CONCLUSION

Bank opening plan is an important factor affecting operating cost and passenger satisfaction.Domestic and foreign scholars have made a lot of explorations on related issues and achieved certain results, but there are still some problems, such as the establishment of a balanced passenger flow allocation model in some studies, and its scientific application in the field of rail transit needs to be demonstrated. For example, most of the literature examples are small in scale, and the proposed method is suitable for large-scale networksThe computation efficiency of network is not clear.The future research should focus on the practicability of the model, the efficiency of the algorithm and the scientificity of passenger flow processing.Under the condition of track network, different stopping modes and variable combinations are combined with complex intersections to adapt to the development of track network. In view of the lack of domestic research on Y-intersections, it is necessary to deepen the research on Y-intersections.

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