Research Article

Analysis on the Effect of Intelligentization and Improvement of Tourist Bus Loops Based on Markov Chain Decoupling

Shousheng Chai,¹ Jun Shan,¹ Chunfeng Long,² and Wang Qianyi³

¹School of Management, Ocean University of China, Qingdao 266100, China
²School of Business Administration, Chongqing Technology and Business University, Chongqing 400061, China
³Economic School of Shandong Technology and Business University, Yantai, Shandong 264500, China

Correspondence should be addressed to Chunfeng Long; long_cf@ctbu.edu.cn

Received 26 May 2022; Revised 22 June 2022; Accepted 1 July 2022; Published 21 July 2022

Academic Editor: Hangjun Che

Copyright © 2022 Shousheng Chai et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Based on vehicle positioning and remote data transmission technology, a quantitative analysis method for the impact of intelligent tourist bus loops on the choice of transportation means between tourist attractions is developed. Aiming at the problem of undirected graph path planning where the influence of time series is known and the edge weights are known, Markov chains are introduced on the basis of the “0-1-like planning under time series” model, and a Markov chain-based algorithm is established. In this article, we proposed a model for route planning of a tourist bus. When solving, it is assumed that the weight of the edge changes with time, and random variables are introduced, but the past state will not affect the current state, and other conditions remain unchanged. After the constraint model is established, it is simulated by computer and solved using the stochastic gradient descent algorithm. The model makes the tour bus loop intelligent and has good interpretability and robustness.

1. Introduction

With the development of economy, holiday tourism is more and more popular among people. Every city regards tourism as an emerging industry and increases efforts to build and improve tourist attractions [1–3]. However, holiday tourism also greatly increases traffic. Especially during the long holiday, the traffic demand of various tourist cities has caused great pressure on the city’s transportation network. Drawing on the advanced experience of developed countries, it is necessary to improve the supply of tourism transportation in tourist cities, especially the accessibility of scattered tourist attractions. This paper proposes a scheme and method for building an intelligent tourism bus loop based on Markov chain decoupling and develops a quantitative analysis model to evaluate the system’s choice of transportation means between scenic spots.

The main purpose of the tourist bus loop is to provide services for tourists who move between scenic spots. It should connect the main scenic spots in the city, and at the same time, it can enable tourists to reach any major scenic spot by one bus. At present, China’s urban tourist attractions are relatively scattered, especially a considerable number of tourist attractions are located on the edge of relatively remote cities, so the accessibility of urban attractions on the bus network is very poor [4–7]. In order to improve urban tourism traffic conditions and provide tourists with comprehensive bus services, it is necessary to set up circular bus routes so that tourists can enjoy one-stop bus services when moving between scenic spots. The intelligent public transportation system refers to the real-time information exchange between the vehicle station, the scenic spot, and the control center, so as to realize the flexible operation and management of the vehicle, the adjustment of the number of people in the park, and the reasonable arrangement of tourism for tourists. The construction of an intelligent tourist bus system in a developed tourist city can provide experience and methods for the construction of the whole city’s intelligent transportation system IST [8–10]. In order to reasonably grasp the tourists’ understanding and needs of
the intelligent tourism bus loop, a questionnaire survey was conducted among tourists in Dalian, and a total of 104 valid answers were obtained, which were composed of 7% by car, 12% by taxi, 70% by bus; tourists’ satisfaction with public transportation between scenic spots is 20%, very satisfied or %, dissatisfied or %, slightly satisfied 60%.

After clarifying the necessity of building an intelligent tourism bus line, its spatial orientation has become a prerequisite for meeting the requirements of tourists. The spatial layout must first be able to connect with the main scenic spots in the city; it should try not to overlap with conventional buses; the scenery on both sides of the line should be beautiful. The purpose of introducing an intelligent system is to achieve interaction between traffic suppliers, traffic demanders, and scenic spot operators. The core technology of intelligent tourism loops is automatic vehicle positioning system (AVL) [11, 12]. Many cities are equipped with bus vehicles. With AVL equipment, the system has the following functions: (1) real-time monitoring of the dynamics of running vehicles in order to improve fleet management and improve running schedules; (2) providing passengers with real-time vehicle arrival forecast information at stations; and (3) implementing the bus signal priority to locate each vehicle. This paper designs a travel bus loop intelligence based on Markov chain decoupling. Aiming at the problem of undirected graph path planning where the influence of time series is known and the edge weights are known, in order to simulate the situation that the degree of traffic congestion changes with weather changes in reality, based on the model of “class 0-1 planning under time series,” the Markov chain is introduced, and a multi-objective path planning model based on the Markov chain is established.

2. Theoretical Background

2.1. Intelligent Tourism Bus Routes. To determine which improvements would increase the attractiveness of public transport, we designed a questionnaire. Three questions are designed. Is it necessary to display the running status of vehicles on the route on the bus stop sign? Is it necessary to display the admission status of each main scenic spot in the bus? Is it necessary to open the intelligent communication between the main tourist attractions? In terms of the necessity of displaying vehicle operation information at bus stops, 8% think it is not necessary, 2% think it is unnecessary, 24% think it is basically necessary, and 6% think it is necessary. In terms of the necessity of garden information, 14% thought it was not very necessary, 2% thought it was unnecessary, 16% thought it was basically necessary, and 68% thought it was necessary.

Using differential global positioning system (DGSP) and wireless communication technology to realize intelligent tour bus loop, information exchange between vehicles and control center and information release between stations and vehicles are realized. The vehicle equipped with the GSP receiver transmits its coordinates to the control center through wireless transmission, and the control center processes these coordinates to obtain the arrival time of the next vehicle at each station and then displays the time on the display screen of the station through data transmission. At the same time, each scenic spot transmits its congestion level to the control center by playing at a certain time interval, and the center then publishes the information on the station and vehicles in a zero-delay manner. The technology required for the entire system is formed. The technology and the price of its products are not high, which is suitable for tourist cities with certain financial resources.

2.2. Markov Chain. A Markov chain is a stochastic process with Markov properties in probability theory and mathematical statistics that exists in discrete exponential sets and state spaces [13]. Markov chains that apply to sets of continuous exponentials are called Markov processes but are also sometimes regarded as a subset of Markov chains, i.e., continuous-time Markov chains, which correspond to discrete-time Markov chains. Therefore, Markov chain is a relatively broad concept.

Markov chains can be defined by transition matrices and transition graphs. In addition to Markov properties, Markov chains may be irreducible, recursive, periodic, and ergodic. An irreducible and normally recursive Markov chain is a strictly stationary Markov chain with a unique stationary distribution. A limiting distribution that traverses a Markov chain converges to its stationary distribution.

A Markov chain is a set of discrete random variables with Markov properties. Specifically, for the set of random variables in the probability space with a one-dimensional countable set as the exponential set, if the values $X = s, s \in S$ of the random variables are all in the countable set and the conditional probability of the random variable satisfies the following relationship [14]:

$$P(X_{t+1}|X_t, \ldots, X_1) = P(X_{t+1}|X_t),$$  \hspace{1cm} (1)

then $X$ is called the Markov chain, the countable set $S$ is called the state space, and the value of the Markov chain in the state space is called the state. The Markov chain defined here is a discrete-time Markov chain, and although it has a continuous exponential set, it is called a continuous-time Markov chain, but it is essentially a Markov process. Commonly, exponential sets of Markov chains are called “steps” or “time steps.”

The above formula defines the Markov property while defining the Markov chain, which is also called “memoryless,” that is, the random variable at step $t + 1$ is given the random variable at step $t$ and the rest of the random variables. The variables are conditionally independent. On this basis, Markov chains have strong Markov properties. That is, for any stopping time, the states of the Markov chain before and after the stopping time are independent of each other.

3. Intelligent Model of Tourist Bus Loop Based on Markov Chain Decoupling

The path planning problem is to plan an optimal path after a given goal and cost. Different combinations of conditions and goals will produce different planning problems. For example, the planning of multiple goals is multi-objective
planning [15], and the loss can be abstracted into yes or no, which is a 0-1 plan. According to the basic Markov chain model in Section 2.2 and the conversion rules between random Petri nets and Markov chains [16], an intelligent model of tourist bus loops based on Markov chain decoupling can be constructed. The algorithm flowchart is shown in Figure 1. After the Markov chain is constructed, the time factor needs to be introduced.

Markov chain is widely used in the analysis and modeling of systems with random processes. It regards time series as a random process and then determines the changing trend of things by calculating the initial probability and state transition probability of the same state. The bus departure and arrival time series is regarded as a random process, and the Markov chain is used to predict the state change of single-line intelligent bus and estimate the delay propagation probability. The evolution process of delays with time and space is regarded as a non-stationary Markov chain, and the arrival/departure delays of smart buses in consecutive stations are defined as random variables and classified into early, small, and large states, and the probability distribution of delays is predicted, and the prediction accuracy is 71% increase. All the above studies have achieved good results, but the influence of joint delay on the transmission process cannot be considered alone. In this paper, the Markov chain is used to intelligentize the tourist bus loop. The research assumptions in this paper are as follows. (1) The bus operation is based on the map. If the delay propagation process between trains is determined, then the train’s on-time delay status remains unchanged, and the propagation probability remains 1. However, there are still random disturbances in the actual operation process, such as the influence of bad and abnormal weather, equipment failures and human operation errors, and so on, and there are differences in the driver’s operation. The influence of the difference of traction and braking performance of EMU, as well as the situation that the passenger car uses the redundant time to rush to the point, are random events based on the graph driving. So, these events can be described by probability model. (2) Redundancy time, including station interval operation, tracking operation, redundant time, and so on, is mainly used to control the delay propagation intensity and improve the delay recovery ability. This paper studies the intelligentization of tourist bus routes because the speed scale of tourist buses in the interval is basically the same, that is, the front and rear buses can be used.

When the initial state vector of the train is \( T = \{1, 0, 0\} \), with the increase of the interval between arrivals, the probability of joint delay gradually increases, but the probability of joint delay is always smaller than the other two delay probabilities. When \( T = \{0, 1, 0\} \), with the increase of arrival interval, the probability of joint delay gradually increases. In addition, the probability of initial delay gradually increases. In addition, the probability of joint delay of the first train after the joint delayed train is also high. If the homogeneous Markov chain starts from three different initial states, after 6 arrival intervals, the probability of each train arrival state is basically stable. It can be shown that regardless of the distribution of the initial arrival state, after 6 probability transitions, a stable state will always be reached. It can also be shown that when the joint delay propagation range of the intelligent bus is 6 buses, the following bus is no longer affected by the current delay state. Combined with the above analysis, since the state transition probability of each station is different, in the scheduling adjustment, it is necessary to pay more attention to the high probability of delay propagation, especially the stations that are likely to cause long delays, and organize trains to catch up in the forward interval.

4. The Impact of Intelligent Tourism Loop on Traffic between Scenic Spots

Since the annual total number of tourists in a city and the traffic demand between scenic spots can be regressed through statistical data, the key to quantitative analysis is to accurately predict the impact of the system on the choice of transportation means between scenic spots after the system guides people. The maximum likelihood utility theory is considered to be the most effective and conventional method when selecting means, and the analysis method is structured as follows:

\[
P_i = \frac{U_i^a}{\sum_j U_j^m} \quad (2)
\]

where \( U \) is the utilization utility of transportation means \( i \). It varies according to personal preferences, and the reason for this contingent variable is that some passengers do not always use the most efficient means of transportation. \( P_i \) represents the probability that the passenger chooses the means of transportation \( i \).

Equation (2) is a very typical mode of transportation means selection. The form of the function \( f(x) \) is usually linear, exponential, or logarithmic, and the unknown coefficients need to be calibrated by regression using the existing data. The advantage of this method is that it has sufficient theoretical basis and is easy to understand. The disadvantage is that it requires a large amount of existing data to calibrate the unknown coefficients, and the calibrated coefficients reflect the behavioral awareness of people in the past, and there may be large errors in the prediction of the future. The intelligent tourism bus loop is a brand-new means of transportation, there is no existing data to use, and there are some unquantifiable elements in the subjective evaluation of the means of transportation between scenic spots by tourists, so it is difficult to obtain the open intelligent transportation by using the conventional utility function. This paper proposes to use the analytic hierarchy process to calculate the utility of various means of transportation between scenic spots. The analytic hierarchy process (AHP) was proposed by an American operations researcher. The advantage of AHP is to determine the
importance of various factors in people’s subjective consciousnes when making decisions through questionnaires, so as to quantify people’s subjective consciousness $I$ in the decision-making process. The choice of transportation means for tourists to move between scenic spots is also a decision-making process. According to a large number of previous studies, it is reasonable to believe that the factors $(X_i)$ that affect tourists’ decision making include cost $(x_1)$, time $(x_2)$, comfort level $(x_3)$, and information provision $(x_4)$.

In order to use AHP to calculate the utility of various means of transportation, a hierarchical structure is designed. Generally speaking, the top layer obtains the priority of tourists’ subjective awareness of each means of transportation. Since tourists do not always choose the most transportation, some contingent factors can also influence their final choice. So, the chance factor is entered into the equation (1) as the utility of the various vehicles. So, the probability of each vehicle being selected is calculated. The second layer refers to the factors that affect the choice of transportation means for tourists, in which cost and time are continuous numerical indicators, while comfort and information provision are qualitative indicators, which are quantified here using discrete indicators.

When using AHP to make decision-making judgments, weight data must be obtained through surveys. The weight is determined by integrating the subjective consciousness of experts in the corresponding field, but most studies calculate the weight by conducting a sample survey of all relevant personnel. Here, the weight of each factor is determined by conducting a questionnaire survey of tourists at the scenic spot. In order to determine the effect of tourists on the four elements of the second layer in the means of transportation and to avoid contradictions in the pairwise comparisons, here, according to the order of the elements arranged by the experts, the respondents are asked to make a stepwise comparison. According to the traditional practice of the AHP method, the importance is assigned to the corresponding value, where very important $=5$, important $=3$, not very important $=1$, not important $=0$, and then 104 answers are counted.

In order to determine tourists’ awareness of the four aspects of various means of transportation in the second layer, the purpose is to find the critical value that tourists care about each element. Through statistical analysis of the survey results, the proportion of tourists who care about each element and various states is obtained. The marginal value of cost difference that tourists care about: 2-6 yuan accounts for 29%, 6-10 yuan accounts for 43%, 10-12 yuan accounts for 20%, and 12 yuan accounts for 8%. The time boundary value that tourists care about: 31% below 10min, 33% 10-20min, 20% 20-30min, 2% 30-40min, and 14% above 40 yuan. Boundary values for comfort differences: 14% accept no-seat crowding, 18% may have a seat, 24% are seated but not crowded, and 4% have a seat. Smart supply boundary value difference: 8% is slightly needed, 2% is not needed, 24% is needed very much, and 66% is needed%.

Combining the above survey results, we can get the priority matrix of various means of transportation relative to each element.

According to the above route layout and survey results, AHP can be used to quantitatively analyze the effectiveness of various means of transportation between tourist attractions. However, due to the large OD matrix of tourist
attractions, it is impossible to calculate the utility of various means of transportation for each OD. In this paper, the average value of OD is used to quantitatively analyze the utility of various means of transportation between scenic spots. According to the model results, we give the priority matrix of tourism bus intelligence in 4 aspects (Table 1). It can be seen that information provision is the most important demand in the loop line performance bus. Then, there is comfort, time, and expense. This is because the price of bus loop travel is relatively low and does not fluctuate much.

5. Improvement of the Tourist Loop

Since the 21st century, country's social economy has continued to develop and various systems have been continuously improved and perfected. The improvement of people's living standards has led to the vigorous development of leisure tourism. Faced with the current development background and strong development impetus, the state has formally incorporated leisure tourism into the major strategic plan of national development, and tourism development is regarded as an important strategic plan for implementation and national layout. The new pillar industry of our country's national economy promotes the development of our country's economy. The scenic tourist road itself is also a part of the scenery. It is different from ordinary highways in that it has few freight services and has higher requirements for aesthetics. The characteristics of tourist highways around scenic spots are studied and analyzed, and targeted landscape construction can realize highways. The organic unity with tourism provides a pleasant driving environment for tourists.

In the long-term development process of highway construction and governance, the state usually only focuses on the corresponding construction and maintenance of the use function of the highway but does not pay much attention to the landscape and characteristics of the highway itself, including the surrounding environment, even if there are some highways. In the process of construction or governance, the factors of the environment or landscape are considered, and it is also a relatively superficial governance, or it just stays on the repetition of some simple content, or the decoration and creation of the surface of the road, which leads to the development of the road. The disharmony between the overall structure and the landscape environment will even cause damage to many natural landscapes around the highway and along the route, resulting in environmental deterioration. At the same time, many highways in our country are beautifying the landscape along the route or the surrounding environment. In the process of construction, it only stays on the general greening tree design, and the patterns and methods used are relatively simple, resulting in too monotonous road landscape. No systematic design research has been carried out, so the corresponding road landscape is very scattered, which not only affects the road landscape but also affects the use of highways as a transportation channel to a certain extent. For tourist highways, in addition to satisfying the most basic driving and use functions, the landscape organization along the tourist highway should also be given full attention. Whether the tourism highway landscape organization is reasonable or not plays a pivotal role in the overall planning of the highway landscape.

Tourism highway landscape is a complex landscape, including the landscape formed by the highway itself, as well as the natural landscape and human landscape along its route. The interpretation of tourist highway landscape should pay attention to the following. (1) From the perspective of internal and external scope, the tourist highway landscape not only includes the landscape within the scope of the highway but also includes the sight-seeing landscape outside the scope of the highway. Tourism highway landscape is a combination of various natural and cultural landscapes and highway traffic elements visually seen by highway users. As a highway construction mode integrating tourism traffic and economic development, the landscape construction of tourist highway goes beyond the content and scope of the usual highway landscape. (2) From the perspective of landscape components, the tourist road landscape covers natural landscapes and human landscapes. Natural landscapes include topography and landforms in the natural environment (such as plains and hills, snow-capped mountains, forests, seas, wetlands, deserts, and gobi), animals, plants, celestial phenomena, and so on. Human landscape refers to various artificial structures or settlement landscapes created by human beings in the long social production activities, including various types of towns, suburbs, rural landscapes, and social and cultural landscapes such as transportation facilities, historical sites, and religious buildings. (3) According to the different viewing methods of the tourist road landscape, the tourist road landscape includes dynamic and static landscapes. The dynamic landscape and the static landscape correspond to the dynamic viewing mode and the static viewing mode, respectively, and are suitable for studying the physiological and psychological feelings of the dynamic landscape and the static landscape due to the high-speed driving, slow driving, or stillness of the landscape subjects. Visual view, corresponding space design, and dynamic landscape sequence space design are important techniques and means of landscape composition.

### Table 1: Relative importance of four factors in traffic mode choice.

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Time</th>
<th>Comfort</th>
<th>Information provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>1</td>
<td>2.05</td>
<td>4.63</td>
<td>11.58</td>
</tr>
<tr>
<td>Time</td>
<td>0.49</td>
<td>1</td>
<td>2.26</td>
<td>5.65</td>
</tr>
<tr>
<td>Comfort</td>
<td>0.21</td>
<td>0.44</td>
<td>1</td>
<td>2.50</td>
</tr>
<tr>
<td>Information provided</td>
<td>0.09</td>
<td>0.18</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>The eigenvalue</td>
<td>0.64</td>
<td>0.25</td>
<td>0.08</td>
<td>0.03</td>
</tr>
</tbody>
</table>

6. Conclusion

The establishment of tourist loops in large cities with insufficient urban rail networks will play a significant role in improving the supply level of tourist traffic, improving
tourist traffic services, and improving the soft and hard environment of tourism. The intelligent system of tourist bus loops is based on Markov chain decoupling. The introduction will not only improve the efficiency of a single tourist bus route but also provide experience and methods for the construction of the city’s overall intelligent transportation system. It is entirely possible for the construction of intelligent tourism bus lines to take the line to the surface to accelerate the intelligent process of the urban transportation system.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

References


