City Tour Route Planning Model Based on Improved Floyd Algorithm

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Abstract. On the basis of analyzing current problems of city tour route planning, this paper brings forward city tour route planning model based on improved Floyd algorithm. Firstly, interest sight spot coding and selecting model are set up to form sight spot classification code. Intelligent sight spot element selecting method is brought forward. And then city tour route planning algorithm model is set up according to selected sight spot element and optimal motive iteration output model of the shortest route is obtained. Take Zhengzhou for example, motive iteration values and sight spot guide maps of different tour routes are obtained. Meanwhile, optimal tour routes and several suboptimal routes are obtained, which meet the needs of tourists’ best motive benefit. Example testifies that the algorithm conforms to the reality and it is feasible and practical to intelligent tourism route planning.

Introduction

Before tourists going to visit an unfamiliar city, they should confirm specific sight spots according to interest and scheduling, on which basis tour route should be planned to meet tourist motive benefit. When planning tour route, selected sight spots are set as intermediate nodes. One-way tour route should be time-limited, and each sight spot can only be singly visited. Among many factors, traffic condition is the critical issue that tourists should consider most. City sight spots are relatively dispersive, different sight spots are connected by urban roads, which forms many paths. But not all the paths are optimal. The tour route planned by tourist after selecting sight spots should mostly meet tourist motive benefits, in which route distance, bus number, subway number, taxi fee and traffic light number, etc. are the factors influencing tourist motive benefits.

Currently, tour routes are planned mainly by tourists subjectively planning or through travel agency, which lacks considering tourists’ individual interests. The subjectivity of tour route planning can hardly meet the best motive benefits. Meanwhile, route planning algorithms of current tour GIS only consider shortest route and neglect tourists’ real needs and related dynamic factors of city tour, and the planned routes can hardly meet tourists’ motive benefits. Aim at the problems, this paper brings forward city tour route planning model based on improved Floyd algorithm based on individual interests. This model combines tourists’ interests, city tour characters and dynamic factors to plan optimal tour routes, which meets the tourists’ motive benefits most.

Interest Sight Spot Coding and Selecting Model

Tour city usually contains many sight spots of different kinds. Tourists have different interests, and they will select different sight spots. According to tourists’ interests, city sight spots can be classified as four groups.

Set sight spot set as \( V_i, i \in (0,4] \in Z^+ \). Set \( V_1 \) is park and Greenland, set \( V_2 \) is shopping mall, set \( V_3 \) is venue and set \( V_4 \) is entertainment. According to city specific sight spots, Sight spot set contains a quantity of sight spot elements \( U_j, j \in (0,\max \, j) \in Z^+ \).
Thus, sight classification set vectors containing sight spot elements are
\[
\vec{V}_1 = [V_1U_1, V_1U_2, \ldots, V_1U_{j_1}], \quad \vec{V}_2 = [V_2U_1, V_2U_2, \ldots, V_2U_{j_2}], \quad \vec{V}_3 = [V_3U_1, V_3U_2, \ldots, V_3U_{j_3}] \quad \text{and} \quad \vec{V}_4 = [V_4U_1, V_4U_2, \ldots, V_4U_{j_4}, \max(j_1, j_2, j_3, j_4) = \max j].
\]

If tourists are familiar with sight spots and have interests on some sight spots, they can select sight spots directly according to scheduling. If tourists are unfamiliar with sight spots or have difficulty on selecting, intelligent machine can help to randomly select sight spots. Tourists provide sight spot number and then intelligent machine selects proper sight spots, or tourists firstly choose sight spot classification set according to interests and provide expected sight spot element number in each set, and then intelligent machine selects sight spots randomly.

Select uniform distribution function on \([a, b]\) as random number generator, as formula 1. Tourists select \(n\) kinds of sight spot classification sets, \(n \in (0, 4] \in \mathbb{Z}^+\), and then randomly select \(n_1, n_2, n_3\) and \(n_4\) amount of sight spot elements in each set, \(n_i \in [0, j_i] \in \mathbb{Z}^+\).

\[
F(x) = \frac{x-a}{b-a}, \quad x \in [a, b] \quad (1)
\]

As to \(\forall V_i\), when \(j_i \neq 0\) and \(n_i \neq 0\), transfer uniform distribution function \(F(x)\) once for each sight spot set, \(x \in (0, j_i] \in \mathbb{Z}^+\), and randomly obtain \(n_i\) sight spot element codes. Total sight spot number \(n\) meets formula 2.

\[
n = \sum_{i=1}^{4} n_i, \quad i \in (0, 4] \in \mathbb{Z}^+ \quad (2)
\]

**Tour Route Planning Algorithm Model**

After tourists selecting \(n\) amount of sight spots, intelligent machine plans tour routes according to traffic condition and dynamic factors, which combines tourists’ interests and traffic characters and can mostly meet the satisfaction of tourists’ motive.

Set sight spot element set selected from intelligent machine by tourists as \(P\), in which element sight spot is \(p_k\), \(k \in (0, n] \in \mathbb{Z}^+\). Sight spot element of sight spot classification \(V_i\) is \(p_k\), \(k_i \in (0, n_i] \in \mathbb{Z}^+\).

There is space distance among sight spots. From the former sight spot to the next one, there are many factors influencing tourists’ motive such as route distance \(\lambda_1\), bus number \(\lambda_2\), subway number \(\lambda_3\), taxi fee \(\lambda_4\) and traffic light number \(\lambda_5\), etc. Table 1 shows the influence weight on tourists’ motive, \(S\) is route distance, \(N_1\) is bus number, \(N_2\) is subway number, \(R\) is taxi fee and \(K\) is traffic light number.

<table>
<thead>
<tr>
<th>Influence factor</th>
<th>(\lambda_1)</th>
<th>(\lambda_2)</th>
<th>(\lambda_3)</th>
<th>(\lambda_4)</th>
<th>(\lambda_5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>(S^{-1})</td>
<td>0.1(N_1)</td>
<td>0.1(N_2)</td>
<td>(R^{-1})</td>
<td>(K^{-1})</td>
</tr>
</tbody>
</table>

**Table 1. Each influence weight on tourists’ motive.**

Floyd route planning algorithm deduces distances among \(H\) amount of connecting points when searching the shortest distance between the starting sight spot and terminal sight spot. On the basis of
Floyd route planning algorithm, combining tourists’ interests and needs, traffic condition and city tourism characters, the improved tour route planning algorithm model is set up as following steps.

**Step-1 Ensure Starting and Terminal Sight Spot**

1) when \( n = 1 \), route planning algorithm is not transferred.
2) when \( n = 2 \), ensure one route between the starting and terminal sight spot.
3) when \( n \in (2, \infty) \in \mathbb{Z}^+ \), set \( \forall p_k \) and \( \neg p_k \) among \( n \) amount of sight spot elements of set \( P \) as the starting and terminal sight spot. Then the number of node sight spots is \( n - 2 \).

**Step-2 Permutation and Combination of Tour Sequence**

Tour route traverses all the selected \( n \) sight spots in the way of one-direction and single time. \( n - 2 \) amount of node sight spots are the turning points on the tour route. Set node sight spot set \( Q \) as the proper subset of \( P \) and its element is \( q_t \), \( Q \subset P, t \in (0, n-2] \in \mathbb{Z}^+ \).

When traversing all the \( n \) amount of sight spots in the way of one-direction and single time with the starting sight spot \( \forall p_k \) and terminal sight spot \( \neg p_k \), \( A_{n-2}^n \) kinds of tour routes will be formed. Each route motive iteration value can be calculated after the tour sequence being confirmed.

**Step-3 Route Searching and Motive Value Iterating**

Take one tour route sequence for example, as Figure.1 shows. From the starting sight spot \( \forall p_k \), the route goes through \( n - 2 \) amount of node sight spots and finally ends with terminal sight spot \( \neg p_k \).

\[
\forall p_k \rightarrow q_1 \rightarrow q_2 \rightarrow \ldots \rightarrow q_{n-2} \rightarrow \neg p_k
\]

Figure 1. Tour route sequence containing starting terminal and node sight spots.

The route distance from the starting sight spot \( \forall p_k \) to node sight spot \( q_1 \) is \( S_{g,1} \). The distance form node sight spot \( q_1 \) to node sight spot \( q_2 \) is \( S_{g,2} \). Thus, the distance form node sight spot \( q_{t-1} \) to node sight spot \( q_t \) is \( S_{g,t} \). The distance from node sight spot \( q_{n-2} \) to the terminal sight spot \( \neg p_k \) is \( S_{g,n-1} \).

The total distance of the \( G \) kind tour route is as follows.

\[
S_g = \sum_{w=1}^{n-1} S_{g,w}
\]

(3)

Calculate \( A_{n-2}^n \) kinds of tour routes’ total distance and arrange the values in ascending order, and tour route vector \( \vec{T} \) is obtained, as formula 4 shows.

\[
\vec{T} = \left[ S_{\min}, S_{a_1}, S_{a_2}, \ldots, S_{\max} \right]
\]

(4)

If tourists only consider shortest route, they can directly choose the optimal tour route from vector \( \vec{T} \) to obtain the best motive benefit, and the algorithm ends.
Step-4 Comprehensively Consider City Character and Influence Factors

If tourists contemporarily consider influence factors, algorithm continues. Set the initial motive iteration value from sight spot \( p_{k-1} \) to the next one is \( I_{k-1} \), and then the iteration value will be \( I_k \), as formula 5 shows.

\[
I_k = \sum_{m=1}^{5} I_{k-1,m} \lambda_{k-1,m}
\]

(5)

Thus, the final motive iteration value from the starting sight spot to the terminal sight spot is shown as formula 6.

\[
I = \sum_{k=1}^{n-1} \sum_{m=1}^{5} I_{k-1,m} \lambda_{k-1,m}
\]

(6)

Calculate \( A_{n-2}^n \) kinds of tour routes’ motive iteration values and arrange the values in descending order, and motive iteration vector \( \vec{I} \) is obtained, as formula 7 shows.

\[
\vec{I} = [I_{\text{max}}, I_{b_1}, I_{b_2}, \ldots, I_{\text{min}}]
\]

(7)

When comprehensively consider city character and influence factors, the highest motive iteration value related to the optimal tour route.

Step-5 Select Other Starting and Terminal Sight Spot

There are totally \( A_n^2 \) kinds of selecting methods and \( A_n^2 \) kinds of tour routes. As to each method, restart the algorithm from step 1 and obtain the tour route distance vector \( \vec{T} \) or motive iteration vector \( \vec{I} \). Select the shortest route or the highest motive iteration value as the optimal tour route, tourists can obtain the best motive benefits.

Simulation Example

Take Zhengzhou city for example. Set Zhengzhou interest sight spot codes as table 2 shows. Some tourist makes a request of visiting one Park and Greenland (code①), one shopping mall (code②) and one venue(code③), meanwhile, the route should be short and convenient. Intelligent machine gets the request and randomly selects three sight spots from the sight spot code sets as table 2 shows. The selected sight spots are in bold and underlined.

<table>
<thead>
<tr>
<th>Sight spot code</th>
<th>( V_1 )</th>
<th>( V_2 )</th>
<th>( V_3 )</th>
<th>( V_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( U_1 ) Renmin Park</td>
<td>( U_1 ) Wangfujing</td>
<td>( U_1 ) HenanMuseum</td>
<td>( U_1 ) CenturyPark</td>
<td></td>
</tr>
<tr>
<td>( U_2 ) Bishagang Park</td>
<td>( U_2 ) Department store</td>
<td>( U_2 ) ErqiMuseum</td>
<td>( U_2 ) FountPark</td>
<td></td>
</tr>
<tr>
<td>( U_3 ) Zijingshan Park</td>
<td>( U_3 ) Erqi Uanda</td>
<td>( U_3 ) Gallery</td>
<td>( U_3 ) WaterPark</td>
<td></td>
</tr>
<tr>
<td>( U_4 ) Forest Park</td>
<td>( U_4 ) Zhongyuan Unada</td>
<td>( U_4 ) ZhengzhouMuseum</td>
<td>( U_4 ) Science museum</td>
<td></td>
</tr>
<tr>
<td>( U_5 ) Lvecheng Square</td>
<td>( U_5 ) Dehua street</td>
<td></td>
<td>( U_4 ) Aquarium</td>
<td></td>
</tr>
<tr>
<td>( U_6 ) Botanical garden</td>
<td>( U_6 ) CC mall</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use the algorithm set up in the paper to calculate the six tour route motive iteration values and get the result as table 3 shows. Figure.2 is the guide maps for the six tour routes.
Table 3. Selected sight spots and the calculated data.

<table>
<thead>
<tr>
<th>Route</th>
<th>Iteration index(former 2)</th>
<th>Iteration index(latter 2)</th>
<th>Iteration value</th>
</tr>
</thead>
<tbody>
<tr>
<td>①②③</td>
<td>0.102 0.500 0.100 0.043</td>
<td>0.143 0.189 0.400 0.100 0.071 0.083</td>
<td>1.731</td>
</tr>
<tr>
<td>①③②</td>
<td>0.158 0.400 0 0.064 0.125</td>
<td>0.208 0.400 0 0.077 0.100 1.532</td>
<td></td>
</tr>
<tr>
<td>②①③</td>
<td>0.115 0.400 0.100 0.053 0.063</td>
<td>0.159 0.400 0 0.063 0.125 1.478</td>
<td></td>
</tr>
<tr>
<td>②③①</td>
<td>0.189 0.400 0.100 0.077 0.083</td>
<td>0.154 0.400 0 0.067 0.071 1.541</td>
<td></td>
</tr>
<tr>
<td>③①②</td>
<td>0.155 0.400 0 0.065 0.071</td>
<td>0.102 0.500 0.100 0.043 0.143 1.579</td>
<td></td>
</tr>
<tr>
<td>③②①</td>
<td>0.208 0.400 0 0.077 0.100</td>
<td>0.115 0.400 0.100 0.053 0.063 1.516</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Tour route guide maps.

From the motive iteration values, it can be concluded that the tour route of Zijingshan Park, Erqi Uanda and Zhengzhou Museum can output the highest motive iteration value, which can confirm the shortest distance and obtain the best motive benefits in the optimal way. The tour route of Zhengzhou Museum, Zijingshan Park and Erqi Uanda is suboptimal. Intelligent machine pushes the optimal and some suboptimal tour routes to tourists and provides tour guide maps as well as tour guide information, which helps tourists to rapidly obtain related information.

Conclusions

On the basis of analyzing current problems of tour route planning, this paper brings forward city tour route planning model based on improved Floyd algorithm, which fully considers tourists’ interests and gets the shortest route. It calculates the motive iteration value of tour routes containing all interest sight spots and finally gets the optimal route as well as suboptimal ones. It helps tourists to get the best motive benefits. Simulation example shows that the algorithm conforms to the reality, and it is feasible and practical to intelligent tour route planning.

References


