Research on Pedestrian Route Planning Algorithm Based on Low Exhaust Intake

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Abstract. The main pollution source of urban air quality is vehicle exhaust pollution, in which a variety of toxic and harmful substances seriously affect the health. In this paper, a pedestrian path planning algorithm based on low exhaust gas intake is proposed. The vehicle exhaust collection device is used to collect and analyze the concentration of harmful gases on the road edge, and calculate the air quality index of each section by AQI calculation method. In order to reduce the intake of harmful gas in the existing road network model, the route planning of the minimum harmful gas intake from the starting point to the destination node is given by using the A* search algorithm. Experiments show that the algorithm can effectively avoid the large traffic flow and serious air pollution section.

Introduction

At present, the whole country weather, the number of fog and haze presents the trend of annual growth, more than 20 provinces in the country, more than 100 cities air quality reached severe pollution situation. In March 2015, the Ministry of Environmental Protection released pollution sources analysis results of 9 key cities of air pollution prevention and control. The results showed that the main sources of pollution in Beijing, Hangzhou, Guangzhou and Shenzhen were all [1] of motor vehicle exhaust. In addition, Zhang Yajing of the Tianjin University, also through the analysis of the road on both sides of the air quality index (AQI), and the difference of authority of air quality index of pollutant concentration and the road distance relationship, in order to verify the motor vehicle exhaust is the main pollution source of [2] City, on the road on both sides of the air pollution index and air quality monitoring sites released by the API index in the study, found the road on both sides of the AQI index was significantly higher than the published AQI index even reached 3 - 5 times the difference. The main components of vehicle exhaust are: carbon monoxide, polycyclic aromatic hydrocarbons, lead compounds, toxic particles such as respirable particles less than 10mm in diameter, which can cause chronic bronchitis, emphysema, lung cancer and other diseases [3,4,5]. Therefore, it is the purpose of this paper that how to reasonably plan the path, so that pedestrians can effectively avoid the serious pollution of motor vehicle exhaust, and reduce the amount of pollutants collected in the air.

Scholars at home and abroad have made a lot of research results in the field of road network model. Cao Zhengcai [6] put forward the road for the basic elements, the relationship between road traffic information and road network, from network information and traffic information representation method and path search efficiency aspects, set up to meet the demand of actual road network model; literature [7] methods to construct the network topology model based on trajectory, by detection of topological relation model of road network extraction of key points, based on the space partition set and network topology model of the original trajectory data mining sequence data conversion and frequent pattern. Demir and other [8] construct a clustering hyper-graph model, and reduce the storage capacity of road network data by transforming the node based data storage mode into the data storage method based on the road section.

Pedestrians when the harmful gas is exposed in the link, the different concentrations of intake is not the same, according to the established network model information between the existing roads between the introduction of harmful gas intake parameters in the model, a search algorithm of Lu
Wangmo inhalation of air pollution and fast path based, and its effectiveness is demonstrated in practice application.

**Road Network Model (RNM)**

Road network model (RNM) modeling idea is to take the road as the basic element of modeling, save a lot of traffic information on the road, reduce data storage redundancy, improve the efficiency of network search query [9]. The characterization of harmful gas concentration is carried out according to the environmental protection standard of People's Republic of China: ambient air quality standard (GB3095-2012).

**Air Quality Index**

According to the measured concentration of pollutants in motor vehicle exhaust, the air quality index (Individual Air Quality Index, IAQI) was calculated according to the air quality index and the corresponding pollutant concentration index table.

\[
IAQI_p = \frac{IAQI_{HI} - IAQI_{LO}}{BP_{HI} - BP_{LO}} (C_p - BP_{LO}) + IAQI_{LO}
\]

In this formula: \(IAQI_p\) is air quality sub index for pollutant project \(P\);
\(C_p\) is the mass concentration value of \(P\) for pollutant project;
\(BP_{HI}\) represents the high level of pollutant density limit;
\(BP_{LO}\) represents the low level of pollutant density limit;

The second step is to select the maximum value from the IAQI of each pollutant to determine AQI, and when AQI is greater than 50, the maximum pollutant of IAQI is determined as the primary pollutant:

\[
AQI = \max\{IAQI_1, IAQI_2, IAQI_3, \ldots IAQI_n\}
\]

In this formula: \(IAQI\) is sub index for air quality;
\(n\) stands for pollutant project.

**Intake of Respiratory Tract Pollutants**

When pedestrians walk in the non motorized lane, they are exposed to the serious air pollution of motor vehicle exhaust. A large number of domestic and foreign scholars have studied the inhalation of toxic and harmful gases, and the formula of the intake of pollutants through the respiratory tract is approved by the domestic scholars[10]:

\[
E_a = (C \times RR \times CF)/BW
\]

In this formula: \(E_a\) represents Intake of pollutants through the respiratory tract(mg/kg·d⁻¹);
\(C\) stands for the density of pollutant(mg/m³);
\(RR\) is human breath rate(m³/d);
\(CF\) is transfer factor, as 100%; (absorption rate);
\(BW\) is weight(kg)

Among them, the ambient air pollutants were exposed to the concentration of pollutants, the respiratory rate of the population was 15m³/d, and the adult weight was 65kg.

**Establishment of Road Network Model**

RBM is a combination of network information and traffic information, not only to retain the network connectivity, and traffic information rich, it is the traffic network entity in hierarchy abstract object model layer hierarchical model, the direct and objective entity correspond to accurately describe the complex traffic system.

According to the modeling idea of RBM, RBM is expressed as[9,11,12]:

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\[
\left\{ \begin{array}{l}
R_m = (R, I) \\
R = \{ r | r \in \text{Route} \} \\
I = \{ i | i \in J \}
\end{array} \right.
\]

In this formula: \( R_m \) represents road network, 
\( R \) is a set of roads in the road network, whose elements are the collection of each road information; 
\( I \) is a collection of road relations, whose elements are two sets of road relational information.

\[
\text{Route} = (\text{road_id}, \text{road_info}, \text{road_i}, \text{road_AQI}, \text{road_segment})
\]

In this formula: 
\( \text{road_id} \): Unique ID of each road. 
\( \text{road_info} \): The basic information set of the road, which contains the road name, length, road level and other information. 
\( \text{road_i} \): The order relationship between the current road and other roads. 
\( \text{road_AQI} \): Air quality index of current road. 
\( \text{road_segment} \): The curve section of a road which is connected with the road as \( \text{road_segment} \in \text{Route} \). Its composition is as follows:

\[
\text{road_segment} = (n_{id}, n_x, n_y)
\]

In this formula: 
\( n_{id} \): Numbering of each inflection point; 
\( n_x \) and \( n_y \): Inflection point of GIS geographical coordinates; 

According to the position of Road intersection, the intersection form is divided into t, cross, and star around Sancha and five categories. The road relationship in RBM refers to the intersection of the two roads. According to the characteristics of the actual traffic intersection, the road relationship is defined as follows: 

Definition: Road relations

\[
J = (r_1, r_2, i_{id}, n_{nd}, cr)
\]

In this definition:
\( r_1 \) and \( r_2 \): ID of nodes in two paths 
\( i_{id} \): The frequency of road relations on two roads 
\( n_{nd} \): \( r_1 \) and \( r_2 \) Location information set at the road relation 
\( cr \): Steering information at intersection of two roads

2.4 Path search algorithm::

A* algorithm is first proposed by Hart, Nilsson, Raphael et al. The algorithm speeds up the search speed by introducing the evaluation function, and improves the accuracy of the local preferred algorithm search, thus obtaining a wide range of applications. The evaluation formula of A* algorithm is:

\[
f(n) = g(n) + h(n)
\]

In this formula, \( f(n) \) is the evaluation function of node \( n \), \( g(n) \) is the actual cost from the initial node to the N node in the state space, \( h(n) \) is the estimation cost of the best path from \( n \) to target node. Obviously, \( g(n) \) is real and certain, \( h(n) \) is just an estimate function, also known as heuristic function[13]. In this paper, \( g(n) \) represents the total amount of pollutants inhaled from the starting point to the current node, \( h(n) \) stands for distance estimation from the current node to the destination node.

In order to achieve the optimal path of A* algorithm, two queues are set up, open and close, and the open queue represents the nodes that have not been selected. Close represents the nodes that have been selected, and first puts the starting point into the open list.

The second step is to traverse all the open lists, find out the node with minimum \( f(n) \) value, and put it into the close list, ignore the 8 adjacent nodes near the node where they can't arrive or have close lists; do not add the open list to the open list, and set the node to the father node, and calculate the
value of \( f(n), g(n) \) and \( h(n) \). If open list already exist, check whether \( g(n) \) is smaller than the current parent node to the starting point, and if it is smaller, set the node to the father node.

The third step is to repeat the second step until you add the endpoint to the open queue, which means that you have found the optimal path, or the open list is empty, indicating that the path is not found.

**Field Test Results**

In order to obtain the experimental data of air quality index of the sidewalk, placing the middle position of the vehicle exhaust gas collecting device of each road in the experimental area of (as shown in Figure 1, the concentration of main spot position) acquisition and analysis of motor vehicle tail gas collecting device of motor vehicle exhaust emissions of \( \text{NO}_x, \text{CO}, \text{SO}_2 \) and other gases. The area of Hangzhou is Xihu District, the traffic in the area is numerous, covering many roads, in order to make path planning has the practical significance, the road there are many different paths up to, and the traffic flow distribution is not uniform, resulting in great differences of the concentration of pollutants in the air.

![Figure 1. Schematic diagram of vehicle exhaust gas sampling device placement.](image1)

Motor Lane

Sidewalk

the vehicle exhaust gas collecting device

![Figure 2. Example of road path planning.](image2)

A: Route obtained by shortest path algorithm

B: The best route obtained by the minimum intake of human body

Figure 2. Example of road path planning.
The starting point is set in the China Science and technology building, end point set in Green gardens, in this area, Wensanlu Road City Road, traffic flow, parallel with the star road as branches, traffic is small. When the harmful gas intake is not considered, the pedestrian walking path planning diagram is shown in Figure 2 (a), and the shortest path is calculated by default. Pedestrian a total of 1450 meters. Figure 2 (b) is the best path to consider harmful gas intake after the full 1500 meters, pollutant intake was 2.348mg/kg, before the shortest path when intake was 2.822mg/kg, significantly greater than the path optimization after intake, although the distance difference between the two is not big, but because of the air quality index is relatively large gap, resulting in between the degree of harm to the human body also has the obvious gap.

**Conclusion**

Now the pedestrian path planning is based on the shortest path as the goal of planning the line, cannot effectively avoid large traffic flow, in order to solve the problem of pedestrian path optimization, design a path planning algorithm considering human intake of toxic and harmful gas. The real road network is used as the data prototype to verify the effectiveness of the proposed algorithm. The results show that the effective algorithm has important practical significance.

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**References**


