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A Model of the Dynamic Traffic Road Network

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Abstract

Combining with the basic idea of object-oriented modeling and modules modeling, according to the hierarchical relationships, the entities in the road network are abstracted as layer independent hierarchical model. A static and dynamic combination of generalized urban road network model is established. Road and road relationship sub-model of generalized road network model and the data structures information are analyzed. Moreover, real-time traffic information is taken into account, which lays the foundation for the study of dynamic path planning.

Keywords: generalized network model; road relations; real-time traffic information

1. Introduction

With the development of urban transport, traffic is increasing day by day, road network become more and more complex. Traffic congestion and the blocking of roads which confuse the traveler are becoming more and more serious. Facing a series of problems, the vehicle navigation system came into being. Vehicle Navigation system which blends together a variety of high-tech, such as Global Positioning System technology, Geographic Information Systems technology, electronics technology and computer technology, is a branch of the modern intelligent transportation(Sun Shibo et al.,2006). Path planning is a core part of the vehicle navigation system, the main role, which is based on the urban road network information and real-time road traffic condition information, is to achieve the path planning for the user before travel and travel in, and

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guide the vehicle along the optimal route to destination, at last to realize real-time vehicle navigation. Thus it can be seen that the abundant road networks and traffic information is the basis for path planning, at the same time it is the prerequisite and basis for vehicle navigation. At present, the market application of proven vehicle navigation system is mostly based on the static network model, but the face of traffic reality there are many factors of instability, the user does not satisfied with the existing system. Especially when traffic accidents and traffic congestion happen, the static path planning can not make changes in line (Ge Yan et al., 2010).

2. The property structure of the road

The properties of roads have been defined before construction. Road attribute information can be divided into basic properties and transport properties. The basic properties are the features of road itself. Such as road names, road codes, road address, pavement paving and so on. Transport properties is related to the traffic information, including the road type, road grade, vehicles types, traffic direction restrictions, speed limits, etc(Ge Lei,2008). The properties of the network structure as shown in the figure 1.

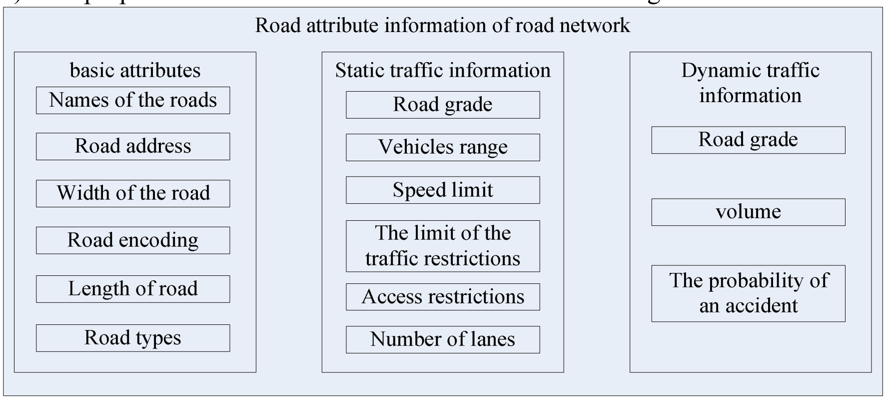

Fig. 1 the properties of the network structure

3. The main level model

3.1. Simulation model

It is the highest level in the model of the entire road network model, including all of the object models of the traffic simulation. A complete traffic network is made up of many roads and the relationships of the roads. Therefore, the simulation environment model is used to uniformly organize and manage these roadways and relations. The model corresponds to the complete transportation network in practice. It includes all the parameters and operations necessary to establish a traffic simulation environment.

The road elements are abstracted into a continuous curve segments with a unique logo and uniform traffic information; Road relationship element is the relationship between the two different roads, determined by the topology on the space and traffic information. According to this definition the simulation environment model is a 4-tuple set: $L=(R, I, O, E)$,where: $R = \{r_1, r_2, \ldots, r_n\}$ is a set which is composed of a limited number of road elements, $I=\{i_1, i_2, \ldots, i_m)$ is a set which consists of a limited number of road relationships, each relationship is represented by the intersection form of two different road $(i_j=r_j\times r_k \mid j, k=1, 2, \ldots, n \text{ and } j\neq k)$. $O=\{ O_1, O_2, \ldots, O_n\}$ $(O_i : r_i \times r_i)$ and $E=\{e_1, e_2, \ldots, e_n\}(e_i=r_i\times r_i)$ are the sets which is made up of limited start points and end points. Road endpoints only mean that they are the start or end point of the road, there are no traffic information. They just show that the road is limited.

Since the entire network topology is determined by road relationship and road, road model and the road relational model is more important of the two sub-models in the simulation environment model. The following is the analysis of these two sub-models.

3.2. Road model

Every road element *r* is a four-tuple *(id, info, c_road, c_i)* in which id is the unique identifier for each road element. The *info* is attribute information collection on the road, including basic properties, static transport properties and dynamic traffic attribute information; *c_road* is the curve information collection of the road. Through each inflection point information on the curve segment in the road reflects the entire road spatial location information. (The inflection point is the point of the road changes in space, including the point which indicates the spatial location information of the curve segment, as well as the point which reflects the position the road relationship happened.) The unique mark of inflection points is stored in order according to the road direction. *c_i* is composed of a collection of road relation and arranged in chronological order with road relations. the *c_i* used to show the roads have relationship with which road and the road relationship and the order and the position of the relationships have happened.

The curve segment information collection of the road elements *c_road* is a list structure which is composed of an inflection point information element *n_road*. In which every element is a triple *n_road=(n_id, n_x, n_y)*. *n_id* is the inflection point identification *n_x* and *n_y* are the Euclidean space coordinates for the inflection point. The inflection point information is arranged in the list structure according to the location of the inflection point in the road forward on the chronological order. *c_road* actually stores spatial location information of roads.

c_i the road relationship collection of the road elements is a list structure that the road relationships are arranged in chronological order in accordance with the relationships on the road. The road relationship identifications are stored in the lists in order.

3.3. Road relationship model

Road relationship *I* is a five-tuple relying on the road. $I(R)= (r_1，r_2，cc，i\_id，n\_id)$, r_1 and r_2 are the roads that constitute the relationship and the position where the road relations happen. This location information is expressed by the path length. *i_id* is the identification of the road relations, for determining the number that the two roads occurred road relations. As the point that happens the road relations must be the inflection point on the road, *n_id* corresponds to the inflection point mark in the road elements of the curve segment information collection, uses to describe spatial position information on the road relations. *cc* is an information matrix of the road relationship. Road relations can actually be considered to be an intersection which constituted by the two roads. cc, namely the intersection traffic information, can contains up to 4×4 kinds of traffic information including the forward pass, reverse intersection traffic delay, forward and reverse whether to allow the U-shaped steering, left turn and right turn information, etc. Each road relationship in the generalized road network model is determined by the two roads. For two or more roads intersecting at the point of road intersections, the relationship between each two of these intersecting roads is respectively describes. That is, when more than two roads cross the same intersection, the intersection itself is to be repeated. Although compared with representation of the roads crossing the corresponding node, the number of road relationship that needs to be expressed is greater than the number of nodes; this method can take full performance of steering limit and steering delay of the traffic road network. What's more, due to the average of 15 percent (Caldwen T ,1961)travel time of the urban road network is spent through the intersection. And even if it is forward pass through the intersection should take up a considerable passage of time, the settings of road relationship matrix in the generalized network model fully consider the straight-line traffic delay.

An actual road intersection as shown in figure 2(a) and its direction of the traffic flow as shown in figure 2(b). It consist of road A and road B, and it also shows that road A and road B have road relationship at this point. The road traffic information matrix *cc* (table 1) in the form of traffic cost specifically described the traffic information between the two roads A and B on that intersection. If there are traffic direction restrictions in the road A or B, the traffic information is shown in the form of the empty set; Using a larger value pre-agreed shows the steering limit; and the rest of the value indicates the corresponding traffic cost, this cost can be distance, time and so on.

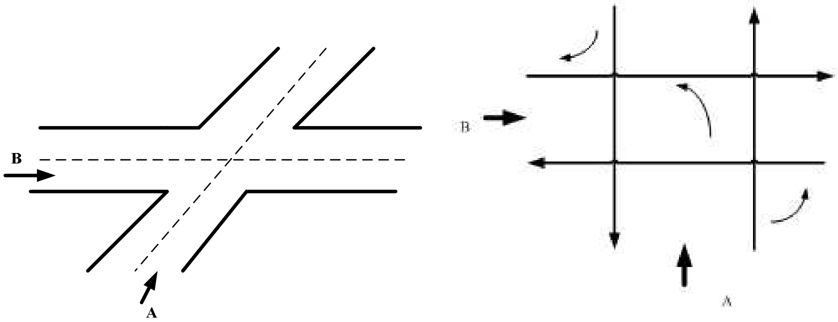

Fig. 2. (a) An actual road intersection (b) the direction of the traffic flow

Table 1. The road traffic information matrix *cc*

	A forward direction	A reverse	B forward direction	B reverse
A forward direction	The cost of going along the road A forward though the intersection	The cost of going forward along the road A and taking U-shaped turn	The cost of going forward along the road A and turning right	The cost of going forward along the road A and turning left
A reverse	The cost of going along the reverse direction of the road A and taking U-shaped turning	The cost of going along the reverse direction of the road A	The cost of going along the reverse direction of the road A and turning left	The cost of going along the reverse direction of the road A and turning right
B forward direction	The cost of going forward along the road B and turning left	The cost of going forward along the road B and turning right	The cost of going along the road B forward though the intersection	The cost of going forward along the road B and taking U-shaped turn
B reverse	The cost of going along the reverse direction of the road B and turning right	The cost of going along the reverse direction of the road A and turning left	The cost of going along the reverse direction of the road B and taking U-shaped turning	The cost of going along the reverse direction of the road B

3.4. Dynamic traffic information model

Dynamic traffic information, including the degree of road congestion, traffic flow, etc.. Such information is also the traffic attribute of the road element. But because such information changes as the real time, their management styles are different from the static transport properties, and they need to be updated dynamically, required to be put forward in particular and special handling. They can be stored in separate data element and associates with other static traffic on the road through the unique identification.

Dynamic traffic information includes not only the specific information of all moving objects on highways and city roads, such as speed, the state of the models, traffic flow, road junctions state, non-motor vehicles and pedestrians, unexpected events and so on, but also includes the comparative analysis between these information and historical data, so that we can determine the trend of change (Qian Hanfeng, Ling Hangfei, 2009).

Data structure for dynamic traffic information:

```
Class Dynamic_info // Dynamic traffic information
{
Int road_ID;// road ID
Int speed;
Char car_type;
Int traffic_flow;
Float Road_Crowd;// Road congestion coefficient (0~1)
}
```

The road congestion coefficient changes from 0 to 1, when $Road\_Crowd \in [0,0.5)$, the road is unblocked. When $Road\_Crowd \in [0.5,0.75)$, the road is slight blockage. When $Road\_Crowd \in [0.75,1)$, the road is serious congestion. When $Road\_Crowd=1$, it shows that the road cannot be used, this condition not only shows road congestion that the road can not be used, also on behalf of road traffic accidents, traffic control, natural disasters occur (Wang Saizheng ,2010)which leads to the road can not be used.

4. Summary

This paper presents the concept of a generalized network model, and on the basis of the static network model, adds dynamic traffic information. It can be seen from the above analysis, starting from the road models and road relational model, a hierarchical, modular transportation network model can be established after a series of system decomposition. Moreover, each transport entity is abstracted as an object model, so you can through expansion of the function of each model to achieve realistic simulation all kinds of traffic behaviors in road network. Also, it is a hierarchical architecture, so that the whole model structure is clear, specific functions, convenient for further perfection.

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