Abstract

A Graphical route information panel (GRIP) benefits transportation induction and alleviating metropolitan congestion. However, facing GRIP, different people give different feedback. The route choice behavior under GRIP derives from many factors. Considering little work paid on the motorists’ route choice behavior under GRIP, in this paper, a traffic model driven route choice simulator is designed in UML. The GRIP module in the simulator is interpreted in detail. A prototype simulator system is also developed in this research.

Keywords: Data Gathering, GRIP, Route Choice Behavior, Traffic Model, UML

1. Introduction

Fast development of transportation benefits urban people’s life. Modern transportation route includes not only common highway and street, but also freeway, subway, magnetic suspension, airline, etc. The transportation vehicles include buses, taxis, trains, airplanes, and so on, which construct a complex city road net. For instance, at the Expo2010, the Shanghai Hongqiao realized its transportation hub of communications. It provides abundant transportation services.

People fell convenient when travelling. At the same time, however, people fell baffled when choosing suitable way. For motorists, this problem often happened. As we know, the taxi drivers will usually choose closest way to the destination for us. If accidents or road maintaining happen in the closest way, they will alter the plan and choose the way with shortest time, even if the way is much longer.

This choosing behavior appears usually, but not certainly. The choosing behavior differs on different human. Some taxi drivers choose the alternative roadway, other elderly drivers may still wait in the closest way. This research focuses on the choice behavior of motorists facing graphical route information panel, which is a new VMS (variable Message Signs) technique[1].

Traditional travel information panel includes fixed text and road section, which induce route choice. In recent ten years, graphical route information panel, GRIP briefly, appear at city freeway in several countries such as Germany, Netherlands, Japan, America and China. It uses several colored light band to indicate the traffic status ahead. Figure 1 shows a GRIP panel in Shanghai city freeway. The green light band denotes the smooth traffic status. The yellow light band denotes the congestion traffic status. If blocked status appears, the light band turns to red color. The color transforming is automatically by the traffic stream data collected by the traffic flow collecting subsystem in the traffic monitoring center.

Figure 1. Graphical Route Information Panel
Due to real-time transportation information, GRIP techniques contribute greatly on the travel induction and reducing the congestion. Compared to traditional route information panel, graphical route information panel GRIP makes complex information easier to understand. Generally, GRIP panel includes variable colors information that indicates the unblocked, congestive and blocked traffic condition. In many countries, the variable red, yellow and green colors in the GRIP indicate the route information. Studying choice behavior before GRIP becomes an important issue in recent years.

In the real situation, it is difficult to gather the motorists' behavior data facing GRIP. Naturally, developing a suitable route choice simulator to acquire reflection behavior data facing GRIP is an efficient method. Currently, as far as we know, there is no work paid on the route choice simulator facing GRIP. To collect and analyze the route choice behavior data, in this research, such a simulator with GRIP is first developed using UML. The data gathered from the simulator help to compute route choosing probability under GRIP, furthermore, it could evaluate how the GRIP improves efficiency of traffic flow in route net. To collect and analyze the route choice behavior data,

The rest of this paper is organized as follows. The second section gives related work upon choice behavior before GRIP. And analyze related simulators research. In the third section, the traffic model driven route choice GRIP-Simulator is proposed. The modules of the simulator are designed in UML in detail. The fourth section illustrated the back ground management of the simulator. The notion of traffic model driven is interpreted. Several UML deployment diagram and activity diagram are designed. In the fifth section, a prototype system is illustrated. This system is coded in C# language and SQL Server database management system. We also give some comparisons with other simulators. Finally we summarize this research.

2. Related Work

In 1991, Mahmassani et al presented a boundedly rational switching rule in order to model route diversion decisions [2]. Koutsopoulos designed a PC based driving simulator that can be used for collecting relevant data in a controlled environment. However, this research did not study GRIP environment[3]. A GRIP provides much more abundant guidance information than traditional traffic information panel. It attracts more and more research in terms of designing and placing of GRIP[4, 5]. Li design a reliable travel route model in congestion environment[6]. However, little work is paid on the motorist reaction and decision making to route guidance of GRIP[4].

Unified Modeling Language (UML) is a standardized general-purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by the Object Management Group (OMG). The first specification of UML was proposed in 1997. UML can facilitate acquaintance and coordination processes and even code generation[7]. UML models can also be applied into model checking to detect problems, which economizes manpower and material resources[8]. Based on the UML diagrams series in the design process, the simulator in this research can be developed conveniently.

Ortis presents a traffic micro simulation model using UML language[9]. He points that the structure of traffic simulation software highly corresponds to the concept of object oriented programming. In recent several years, some scholars modeling their traffic simulators using UML languages[10-12]. Developing a traffic simulator with GRIP faces several difficulties. For one hand, GRIP information in the real world derives from the real time traffic information provided by control center. In the simulator, the varied information on a GRIP depends on the real time traffic information generated by the METANET traffic model[13]. In the section 4, we will also interpret how the GRIP-Simulator driven by METANET model.

3. Traffic Model Driven Route Choice Simulator

General speaking, the GRIP-Simulator is divided into two main part. One is the interfaces which are used by simulative motorists. Another is the background management part which used by the simulator maintainers. In this section, the former part is designed using UML. We give the class diagram of the GRIP-Simulator interfaces, shown in the figure 2.

In this UML class diagram, the dotted arrow denotes the dependence relationship between two classes. The open arrow denotes the inheritance relationship between two classes, here the side with
arrow is the parent class, and the other side is the child class. The solid diamond arrow and the open diamond arrow denote the composition association relationship between two classes and the aggregation association relationship between two classes respectively. The line without arrow denotes the association relationship between two classes.

General speaking, the simulator is divided into four parts. When designing the simulator, briefly, we use four packages to separate and mark the four parts, shown in the following diagram, see figure 3. First is the basic travel information panel. The second is the virtual Scenario panel. The third is the maps panel, including the static map panel and the dynamic map panel. The last is the GRIP panel and the choice panel.

(1) The first part includes two panels, static map panel and dynamic map panel. First, a static route map is loaded into the static map panel. The dynamic map is zoomed in at the location of the black controller. The dynamic map, like a navigator, varies as the location of the controller varies.

(2) The second part is the GRIP and choice panel. As show in the class diagram, the GRIP panel depends on the dynamic map, and the choice panel depends on the GRIP information. As we know, in the real freeway road net, a GRIP panel appears close to a fork.

(3) Speed panel, time panel and mileage panel are basic travel information panels, so they are placed in the package named basic travel information. In the travel process, the mileage and elapsed time and the speed will show in the panel, the speed panel is like an instrument panel in front of the motorist in the real life.

(4) When the virtual travel is started through clicking the start button “start virtual driving”, the controller will go forward constantly. See figure 4. Its location will vary correspondingly. Therefore, the virtual travel panel is composed by cars, controller, pavement and the...
environment. While a motorist starts the travel, he or she should operate the controller in order to keep the controller in the black car, which represents the motorist’s own car. The other red cars represent just the state of a segment in a link. That is, when a motorist enters into next segment, the virtual travel panel refreshes the status. For example, in one segment, the travel state is blocked and the quantity of red cars is excessive. In the next segment, however, the travel status is smooth. The quantity of red cars will be small. For example, eight cars in the figure 4 indicate the traffic status is blocked. This virtual scenario also produces different types of travel scenarios, such as rush hour, fuel price, late for an appointment and so on.

Figure 4. Virtual Driving Panel

4. Back Ground Management

In the whole design of GRIP-Simulator, the back ground management part is the most important due to the realization of traffic model driven road net data.

4.1 Model Driven Virtual Traffic Data Generator

METANET model is proposed by Messmer in 1990. It can describe dynamic character precisely in freeways, including congestion appearing and disappearing. In our research, METANET is chosen as the traffic flow model. In the article [14], Kotsialos interpret the traffic flow model METANET in detail. Our work in this report is just the application of METANET in the GRIP-Simulator.

4.2 Choice Behavior Data Recorder

Following figure 5 is the activity diagram of the simulator. To describe clearly, this activity diagram is separated into three swim lanes, which represent three roles, motorist, recorder and generator. Firstly, a simulator user login the system as a motorist. Secondly, a synchronization Bar denotes three synchronous activities. One is the recording the motorist’s basic information, which will be further studied, joining with the motorist’s reaction behavior data under GRIP. Two is generating a road net through traffic model. Third is starting virtual travel in the road net. The road net data is recorded also in the database. The status travel scenario like weather, type of road, personal preferences is added in the virtual travel scenario. Thirdly, when meeting GRIP information, the motorist has to give his/her route choice on the choice panel. Finally, the route choice behavior data is recorded in the database.
In the interface, the several modules look discrete and independent. In fact, they are interdependent each other. The database that records the choice behavior is very important and should be designed in detail.

Due to lots of drivers in the real road networks facing the GRIP, the simulator should be a multi-user system. Therefore, the simulator can be deployed at many terminals. Then the database is deployed at the server. A client-server mode can be well applied into the designing.

A UML deployed diagram is designed, show in the figure 6. The simulator system is composed by a database server and some clients.

(1) The database server includes two database components. One is for generating virtual travel data. The constantly varied information displayed in the client terminal is driven by these data. The other is for recording the route choice behavior according the travel information in the virtual travel scenario. The data flows are denoted using the bidirectional arrows.
(2) The drivers, sitting front of the client terminal, face the road networks scenario simulator. When he or she clicks the start button using the mouse, the travel begins. The varied information in the several modules derives from the data generated at the server. Some parameters are predefined by the simulator system administrator. When he or she drives close to a crossroad, trigeminal road and so on, the simulator pauses and popups a dialog box which request the driver’s rough choice.

(3) The data generated by the virtual travel data generator is driven by traffic flow models. The basic travel variables include traffic density, mean speed and traffic flow. All the constants, parameters in the traffic flow models are set in an isolated file, which is helpful to control the data using the models.

(4) The Driver behavior is important in this simulator. Before starting the travel, the drivers should input their basic information and basic cars information. In the further analysis, these data will combine the driver’s choice behavior data.

5. Prototype System Illustration

The above two sections design the traffic model driven route choice simulator in UML language. This system could be realized using more than one object oriented programming languages such as C#, java and C++. In this research, we develop a prototype system using C# language in the Visual Studio 2010. The SQL Server 2008 is chosen as the database manager tool.

Table 1 gives the parameters values in the coding. The table displays the utilized model parameter values. The utilized values of \( V_{\text{max}} \), \( \rho_{\text{cr,m}} \) and \( m \_m \) result in a capacity of 2000 veh/h/lane for the motorway links. The capacity of origin links is determined to be \( Q_0 = 1500 \text{ veh/h/lane} \). The time step is set to \( T = 10 \text{s} \). Refer the article for detail interpretation [14].

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( \tau )</th>
<th>( \kappa )</th>
<th>( V )</th>
<th>( \rho_{\text{max}} )</th>
<th>( \rho_{\text{cr,m}} )</th>
<th>( V_{\text{f,m}} )</th>
<th>( \alpha_m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>18</td>
<td>40</td>
<td>60</td>
<td>180</td>
<td>33.5</td>
<td>110</td>
<td>1.636</td>
</tr>
<tr>
<td>Unit</td>
<td>s</td>
<td>veh/km/lane</td>
<td>km/h</td>
<td>veh/km/lane</td>
<td>veh/km/lane</td>
<td>km/h</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Parameters in the METANET Model
Table 2. Start Point Information

<table>
<thead>
<tr>
<th>Occasion</th>
<th>Demand</th>
<th>Position</th>
<th>QueNum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>0.15</td>
<td>57.6</td>
</tr>
<tr>
<td>2</td>
<td>54</td>
<td>0.072</td>
<td>54.72</td>
</tr>
<tr>
<td>3</td>
<td>88</td>
<td>0.0004</td>
<td>83.744</td>
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<tr>
<td>4</td>
<td>78</td>
<td>0.0706</td>
<td>78.1488</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
<td>0.052936</td>
<td>87.02975</td>
</tr>
<tr>
<td>6</td>
<td>102</td>
<td>1.007652</td>
<td>99.005952</td>
</tr>
<tr>
<td>7</td>
<td>114</td>
<td>1.2573744</td>
<td>111.0011604</td>
</tr>
<tr>
<td>8</td>
<td>126</td>
<td>1.3073489</td>
<td>123.0000206</td>
</tr>
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<td>9</td>
<td>138</td>
<td>1.50750287</td>
<td>135.000040616</td>
</tr>
<tr>
<td>10</td>
<td>150</td>
<td>1.657501982</td>
<td>140.000060232</td>
</tr>
<tr>
<td>11</td>
<td>162</td>
<td>1.8375011904</td>
<td>150.000026864</td>
</tr>
</tbody>
</table>

Table 2 shows the vehicles information of start point O1, which is generated using METANET models. See figure 7. In this table, the field Occasion, Demand, WaitNum and QueNum denotes the time, demand quantity of vehicles, waiting quantity of vehicles and inflow quantity of vehicles at the start point O1.

Figure 7. GRIP-Simulator Prototype

The GRIP-Simulator interface is shown in the following figure 7. When we load a static map in the simulator, an initial dynamic map at the start point O1 is generated. The dynamic map derives from the static map. The dashed lines in the dynamic map separate links and segments.

If no GRIP information, The GRIP panel is empty. When the black car approach a fork, an real time GRIP information appear in the GRIP panel. A choice behavior data recorder pop up, and cars in the driving panel pause. The simulative motorist has to give his/her decision and click the OK button. Then the choice data are recorded in the database.

Following figure 8 shows the selected choice data in the database. The table motorist includes four attributes, it gathering five concrete motorists records. The table car includes three attributes, it
gathering the five basic car information of the motorist respectively. The table GRIP choice gathering the choice of the five motorists facing the GRIP panel. These data could be further analyzed and mined to discover the potential patterns and rules. For example, “age <=50” $\Rightarrow$ “choice = B”, and “age =60” $\Rightarrow$ “choice = B” might be two association rules. These choice behavior rules may further improve the travel induction and reduce the congestion. We will further investigate how to apply data mining techniques into choice behavior data analysis.

<table>
<thead>
<tr>
<th>Motorist</th>
<th>Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>age</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
</tr>
</tbody>
</table>

**Figure 8.** GRIP Choice data

6. Conclusion

As far as we know, little work is paid on the route choice behavior facing GRIP information. There is also little work paid on modeling such route choice simulator using UML. The main contributing of this research is designing a GRIP supported route choice simulator using UML. The dynamic real time GRIP information derives from the route data driven by the METANET traffic flow model. The research benefits the further development based on the UML diagram series. The route choice behavior data collected could be further mined to discover inherent knowledge and patterns.

7. Acknowledge

This research is supported by the National Natural Science Foundation of China under Grant No.51008195, the Excellent Youth Scholars of Ministry of Education of Shanghai under Grant No. slg10010, the Innovation Program of Shanghai Municipal Education Commission under Grant No. 12YZ103, and Innovation Plan for shanghai College Students under Grant No. SH1110252068.

8. Reference

[4] H. Gan, "Graphical route information panel for the urban freeway network in Shanghai, China,"


