Research on Road Safety Warning Model of the Intelligent Transportation System

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Abstract — ITS can make the effective use of the existing transportation infrastructure, so that the traffic flow can effectively be distributed in time and space. Using ITS can reduce traffic accidents, ease traffic congestion, shorten the travel time, reduce traffic pollution and improve urban transportation management level. In the paper, the key technology of the car road cooperative technology has been researched, the model which is built in this paper be determined as data prediction model which is belonged to the traffic information processing module internal of the car road cooperative system. Construct the early warning model that based on the car road cooperative technology, and the input and output parameters of the model then be determined, evaluation index which is used to analysis the reasonableness of the model and accuracy of the prediction results. Do the model simulation experiment which is combined with calculating examples, do the comparative analysis of the simulation experiment results. The calculating results show that the model been build has higher accuracy than the traditional model, by calculating evaluation index such as the model correlation coefficient, that the model be built in the paper can be used as the warning model which is based on the condition of the car road cooperative technology.

Keywords - Cooperate Vehicle Infrastructure System; Matlab; Road Safety Warning Model; Logistic Regression

I. INTRODUCTION

Urbanization is a sign of social progress; it’s also a sign of the development of social civilization. In recent years, science and technology developed rapidly, economy and urbanization also accelerated developed. With the accelerated process of urbanization, a wide range of traffic problems come from one another. Urban road intersections is an important part of the urban road traffic system, motor vehicles, non-motor vehicles and pedestrians gather here from all directions of the city, and then through the intersection to change the traveling direction, for this reason, the traffic situation of the intersection becomes complex and changing, makes the intersection become traffic accident-prone area of the urban road. According to relevant statistics, about more than half of the traffic accident occurred at the intersection in the city. Intersection traffic safety problem has become a serious problem that cannot be ignored, therefore it is necessary to study the intersection traffic safety situation, and we can predict the development of the traffic accidents in intersection in advance by analyzing its security situation. Develop appropriate disposal plan for the predicted results, which is based on the traffic safety forecast, the traffic safety warning of the intersection can be realized.

Traffic congestion is another significant problem of urban traffic, it is easy to cause many social problems, such as traffic accident, environment pollution and energy consumption, and so on. CVIS (cooperative vehicle infrastructure system) is considered as cutting-edge. International intelligent transportation and plays an important role to improve the safety and traffic efficiency of urban traffic system. By regulating the traffic posture, urban road congestion can be prevented before it happens. So it can ensure urban road traffic smooth, improve the satisfaction of urban transportation in the citizen's hearts; enhance the good experience of traffic user in city traveling [1].

With the rapid economic growth and the constant increase number of motor vehicles, the safety traffic situation in China has become increasingly grim. According to statistics, 90% of traffic accidents are caused due to the lack of information between the vehicle to vehicle and vehicle to roadside system [2]. Therefore, the cooperative vehicle infrastructure system turns to be an important research topic. However, considering that many of the key technologies are still in the stage of research and the lack of effective verification environment, it's difficult to carry out a large-scale application, which emphasizes the importance to establish a reasonable and effective integrated testing system.

Along with the rapid growths in both car ownership and urban scales, the traffic environment is degradation in China. The problem of ensuring road efficiency and, the most important among others, vehicle safety, is the fundamental task of city development [3]. At the turn of the century, the transportation infrastructure has been improved in many cities. Old urban roads were widened, or replaced by fast road or private roads, in order to improve the people's travel. All the types of these roads are multi-lanes. The emergence of multi-lanes in traffic environment is able to increase efficiency for vehicles and road employing. However, as a cost of introducing multi-lanes, more coupling problems of relations between vehicles also emerged. Due to space limitations, solving the congestion by the improvement of transport infrastructure only is limited. A new solution domain is provided to solve the problem above by Cooperative Vehicle Infrastructure System (CVIS), with its core content of intelligent traffic system (ITS), which pays more attentions on the micro car road traffic object. The condition of future traffic environment, traffic participants
and the corresponding method of planning and control in multi-lanes microenvironment coordination on CVIS are studied.

With the in-depth research in Intelligent Transport System (ITS), a growing number of results show that intelligent cooperative vehicle-to-infrastructure systems will effectively improve road safety and transportation efficiency. The cooperative vehicle-to-infrastructure system (CVIS) obtains the information of the vehicles and roads through information processing, positioning, navigation, communication, and electronic sensor, artificial intelligence, and computer technologies [4]. It provides the real-time information interaction among people, road side units and vehicles in order to achieve the effective collaboration. Based on full-time-space and reliable traffic information collection and fusion.

II. THE COOPERATE VEHICLE INFRASTRUCTURE SYSTEM AND ROAD SAFETY

The cooperative vehicle-to-infrastructure system carries out research about vehicle safety control and road collaborative management to provide reliable traffic information. Meantime, it achieves the goal of optimizing the resources, improving road safety, and easing the traffic congestion.

ITS can make the effective use of the existing transportation infrastructure, so that the traffic flow can effectively been distributed in time and space. Using ITS can reduce traffic accidents, ease traffic congestion, shorten the travel time, reduce traffic pollution and improve urban transportation management level [5]. The Cooperative vehicle infrastructure system, its basic idea is that by using multi-disciplinary integration, make use of a variety of state-of-the-art technology of sensor wireless networks, computer information technology and wireless communication technology, so that achieve coordinated development of the human, vehicles, roads and the mutual smart perception.

Transport system is a typical complex giant system. Relying on traditional traffic management from the perspective of roads and vehicles, it is difficult to resolve worsening traffic congestion, accidents, environmental pollution in recent years. The establishment of transport system integration of people, vehicles and road is based on information exchange between vehicle-vehicle and vehicle-road, which is very important to improve efficiency and security, to achieve sustainable development of transport system. Cooperative vehicle infrastructure system has become the forefront of technology and research focus in the field of Cooperative vehicle infrastructure system [6]. Naturally, security is the focus of traffic; traffic safety is always the focus of cooperate vehicle infrastructure system. With the support of science and technology, new construction, operation and management has been established. V2I system based on advanced sensing and wireless communication technologies, has achieved vehicle-vehicle and vehicle-road real-time information exchange, completed the entire space-time dynamic traffic information collection and integration, which is coming to the new generation of cooperate vehicle infrastructure systems for protecting the safe environment in a complex vehicle traffic, achieving active control of road traffic, and improving network efficiency. Although China has conducted an extensive and thorough research in the field of traffic safety, gained a series of research results, and improved traffic safety situation, without complete information, these technologies cannot solve the entire problems of transportation safety. Accordingly, developing intelligent key technology of V2I will help us to improve traffic safety condition and supply technical reserves.

Comparing the actual path relationship between the vehicles and infrastructure, the basic characteristic of CVIS is that the information of operation and controls between vehicles to vehicles (V2V) and vehicles to infrastructures (V2I). As the way of information acquisition changed, the vehicle’s running state changed at same time. Comparing with rules in two lane environment, changing rules in Multi-lanes environment are more complex and flexible. In particular, when the traffic density is high, the congestion dramatically reduces the efficiency of road.

With the rapid development of our national economy, traffic problems are becoming more and more serious. Cooperate vehicle infrastructure systems (ITS) perhaps are effective ways to solve or alleviate various traffic problems. The main functions of expressway traffic safety early-warning system are to provide corresponding control strategy and prevent the happening of accidents, by the traffic conditions and meteorological conditions, traffic flow characteristics, and so on.

As freeway mileage nearly been completed, China's gained the success that attracted the worldwide attention in this regard, became in the road transportation on freeway powers the world. The rapid development of the freeway has brought very good role in promoting the economic development of China [7]. The freeway management can't keep up with the pace of freeway development. From the high accident rate and serious accident damage in recent years, our country's freeway management has to be improved. To reduce the traffic accident rate, research on early-warning management of expressway traffic accident has become the focus of the work of highway management right now.

We define the expressway traffic safety early-warning system’s main function. The expressway early-warning management has four basic functions: warning, correction, emergency disposal and immunity. Expressway early-warning management can provide the development trend of expressway traffic safety process description based on the judgment of the development status of traffic accident. The system will judge the expressway traffic flow characteristics, and report to the traffic management department in time when it had bad changes, then adopts corresponding counselling maneuver, so plays an important effect for serious accidents (especially super-severe traffic accidents and secondary accidents).

The information demand of expressway traffic safety early-warning system is analyzed. The users can be divided into three categories: the administrator of expressway, the person who participate expressway, and the server of
Expressway [8]. The primary responsibility of the manager is to use various resources and means to ensure the expressway safety operation by macroscopically and microcosmic management. Therefore, they need much traffic information to improve the level of management and service. The users of the expressway can know the safety information by various information release means, and avoid the traffic accident according to traffic misleading information. The server can obtain the expressway traffic safety information by checking system data, then make service strategy and formulate more targeted service for effective operation.

A structure framework of the expressway traffic safety early-warning system is provided. According to the functions, the system can be divided into three subsystems: basic transportation information acquisition subsystem, early-warning information processing system, and information release subsystem [9]. It can fuse all sorts of multi-source data of original traffic heterogeneous come from all kinds of traffic information collection equipment’s, then identify the traffic condition and send out warning information according to the predetermined algorithm.

Intersections are an important part of the road system and are potentially the most dangerous parts of the network because they present a driver with many points for possible conflict with other road users, and in a challenging environment regarding vehicle crashworthiness. With the huge losses to society resulting from intersection crashes, it is important to gain a better understanding of the characteristics of intersection crashes. Traffic accidents are a public health problems that is amenable to treatment using a methodology applied more commonly to disease epidemics. The characterization of the distribution of health-related states or events is one broad aspect of epidemiology called descriptive epidemiology. This technique provides the what, who, when and where of health-related events. In this case, the descriptive epidemiological study of intersection crashes were carried out by descriptive statistics method which summarized the population data by describing what was observed in the sample numerically or graphically.

### III. Road Safety Warning Model

Australian Victoria state’s casualty crash data for the period January 2000 to December 2009 was provided by Vic Roads (which is a statutory corporation, the state road and traffic authority in the state of Victoria, Australia) for use in this study. Intersection crashes were recruited from this dataset [10].

First, a descriptive statistics study of casualty intersection crashes was carried out to generate the frequency of intersection crashes in different categories. In order to obtain an overall indication of the extent of the problems associated with casualty intersection crashes, several variables were chosen from the dataset for more detailed analysis, including definitions for classifying accidents (DCA), speed zone, time of day, day of week, traffic control type and the like.

<table>
<thead>
<tr>
<th>Project</th>
<th>Traffic managements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main road</td>
<td>-</td>
</tr>
<tr>
<td>Secondary road</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
</tr>
<tr>
<td>Traffic</td>
<td>-</td>
</tr>
<tr>
<td>Vehiciles/h</td>
<td>-</td>
</tr>
<tr>
<td>No management</td>
<td>Light</td>
</tr>
<tr>
<td>Marking way</td>
<td>Omnidirectional parking</td>
</tr>
<tr>
<td>Unidirectional parking</td>
<td>Lights</td>
</tr>
<tr>
<td>&lt;1000</td>
<td>&gt;3000</td>
</tr>
<tr>
<td>&gt;3000</td>
<td>&gt;5000</td>
</tr>
<tr>
<td>&gt;5000</td>
<td>&gt;8000</td>
</tr>
<tr>
<td>The number of collisions</td>
<td>&gt;3</td>
</tr>
<tr>
<td>Other factors</td>
<td>Pedestrian, gap, and so on.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Second, the Circular Distribution method was applied to test whether there is an occurrence tendency of casualty intersection crashes. This method, first applied in the medical field, is used to analyse and model distributions of random variables that are cyclic in nature. Because circadian changes in some diseases are seasonal and therefore cyclical in nature, a full circle is used to present the position and time of the occurrence of disease symptoms. Since traffic accidents also have cyclical patterns, the Circular Distribution method has been applied in the traffic accident epidemiological studies [11].

The method was used to analyze casualty intersection crashes by a number of variables, including crash time and day of week, among others. If the characteristic has a central tendency at one moment, the moment is shown in the circle by a (mean angle). The mean angle can be transformed to the corresponding moment, and the highest frequency moment of intersection crashes with the characteristic can be determined, a can be transformed to the corresponding period, and the highest frequency period of intersection crashes with the characteristic can be calculated S is angle standard deviation.

Take the 24 hour accident distribution as an example. Each hour occupies 1/24 of 360 degrees (15 degrees) and is represented by a., with representing the number of the accidents in each hour [12]. The formulas with the angle discrete degree indicator r, mean angle a, and angle standard deviation S is as follows:

\[ X = \sum \frac{f_i \cos a_i}{\sum F_i} ; Y = \sum \frac{f_i \sin a_i}{\sum F_i} ; r = \sqrt{X^2 + Y^2} \]  
(1)

\[ \cos \theta = \frac{X}{r} ; \sin \theta = \frac{Y}{r} \]  
(2)

\[ S = \frac{180}{\pi} \sqrt{-2 \ln r} \]  
(3)

The angle discrete degree indicator r is used to test the statistical significance of the mean angle. If rooms (the reference value), the mean angle is significantly and there is a highest frequency moment of the intersection crashes with the characteristic. r can be obtained from the reference table.
According to the survey of urban road traffic flow, the number of road traffic accidents, pedestrian dense degree, and the development trend in the future, traffic managements are divided in Table 1.

The three formulas are for the reference formula in the paper:

\[ \sum_{i=0}^{n} C_{n_i}^i > d \]  
(4)

\[ a_i = \sqrt{m + n + a} \]  
(5)

\[ n = \log_2 n \]  
(6)

The n is the number of input units.

The next step is to establish the neural network has been trained; the function train is a function of BP network training.

\[ \text{net} = \text{train} (\text{net}, p, t) \]  
(7)

The net for the already well-established network, p, t representing the input matrix and output matrix, When training in the use of function training, the specific training parameters are as shown in Table 2.

<table>
<thead>
<tr>
<th>Parameter names</th>
<th>Parameter properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>net.trainParam.epochs</td>
<td>Training times</td>
</tr>
<tr>
<td>net.trainParam.show</td>
<td>the number of steps between two training displays</td>
</tr>
<tr>
<td>net.trainParam.goal</td>
<td>Training goals</td>
</tr>
<tr>
<td>net.trainParam.time</td>
<td>Training time</td>
</tr>
<tr>
<td>net.trainParam.min_grad</td>
<td>Minimum performance gradient</td>
</tr>
<tr>
<td>net.trainParam.min_fail</td>
<td>The maximum number of failed confirmation</td>
</tr>
<tr>
<td>net.trainParam.searchFen</td>
<td>Search Path</td>
</tr>
</tbody>
</table>

For the model simulation, the neural network is mainly used sim function simulation:

\[ a = \sin (net, p) \]  
(8)

Regression methods have become an integral component of any data analysis concerned with the relationship between a response variable and one or more explanatory variables. In the logistic regression model, the dependent variable is binary or dichotomous, but the independent variable can be dichotomous or continuous. According to the dependent variable's value, the logistic regression model can be divided into two types: binary logistic regression model, which the dependent variable has two binary values by dummy variables (0,1) and multinomial logistic regression model, which the dependent variable has more than two values by dummy variables (0,1,2...).

In the traffic safety application, the dependent value is always binary, such as killed or not killed, injured or not injured. There are many factors that have a relationship with the dependent variable, such as age, weight, gender, speed, etc. In this study, binary logistic regression was used to examine the influence of various accident factors on a dichotomous outcome. Y denotes the binary dependent variable, and there are only two values for the dependent variable 0/1.7=1 means that a fatal collision occurs and 7=0 means that a fatal collision does not occur. A fatal collision was one in which at least one fatality resulting from the crash occurred within 30 days (7=1), while an injury (non-fatal) collision was defined as a crash in which at least one person was injured but no fatality occurred (7=0). x ^ 2 m denotes the independent variables, which can be categorical values or continuous variables. Set P as the probability of fatal crashes and 1-P is the probability of non-fatal crashes. The relationship between P and x is normally not linear, but curvilinear, as equation 9 shows:

\[ P (Y = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n)}} \]  
(9)

The transformation of the P logistic function is known as the logit transformation, as equation 3.2 shown:

\[ \logit(P) = \ln \left( \frac{P}{1-P} \right) \]  
(10)

The odds of a fatal crash were defined as the probability of a fatal intersection crash occurring divided by the probability of a non-fatal intersection crash occurring, as equation 11 shows.

\[ \text{odds} = \frac{P}{1-P} \]  
(11)

The odds ratio represents the relevant ratio between the odds of the exposure level to the odds of the non-exposure level that can be used to analyze the criticality of the independent variables, as shown in equation 12.

\[ OR = \frac{\text{odds}_1}{\text{odds}_2} \]  
(12)

The odds ratio is equal to esp. such that when an independent variable increases by one unit with all other factors remaining constant, the odds increase by a factor exp. It indicates that relative amount by which the odds of the outcome increase greater than 1 or decrease less than 1 when the value of the corresponding independent variable increases by one unit. In the case of the categorical independent variables in this study, the odds ratios represented the fatality risk comparison among different levels.

IV. RESULTS

We use 20 intersections of data as training samples of simulation experiment. The last six data is used as a test sample simulation experiment. By matlab software, BP network model is trained.
Through analysis of these data, the fit between the predicted value and the actual value of the sample is very high. BP network model constructed in this paper for intersection traffic safety is warning with high accuracy. The model can be integrated into the carriageway traffic information processing module internal coordination system.

V. CONCLUSIONS

A descriptive epidemiological study of intersection crashes was carried out to establish the frequency of casualty intersection crashes by category. The dataset examined was provided by Vic Roads, the state road authority in Victoria, Australia, for the period January 2000 to December 2009. In addition, the circular distribution method was used to investigate temporal patterns in casualty intersection crashes.

Logistic regression is an analysis method used in analytic epidemiology that has been proven to be a reliable means of revealing the relationship between the response and explanatory variables within the road accident domain. In this study, a logistic regression was conducted in order to reveal the risk factors affecting the severity of intersection crashes in Victoria, Australia. The potential risk factors identified included driver characteristics, vehicle features, environment and road factors and crash characteristics.

While the logistic regression method was used as a statistical interpretation tool of intersection crashes, an innovative step was included that employed fault tree analysis (FTA) as a systematic interpretation tool, focusing on the identification of the basic events that can lead to an intersection crash. By constructing a fault tree, this method can describe the logical process from basic failure events (contributing factors) to the top outcome event (intersection crash) to present how the top event happens. During this study a pilot fault tree analysis was produced to categorize the contributing factors to intersection crashes. The data for the analysis was based on interviews conducted with crash-involved, drivers and detailed inspections of the vehicle and crash site. The data used were sourced from the Australian National Crash In-depth Study (ANCIS), which provided detailed information for each intersection crash collected.

Fault tree analysis was used in order to provide a new insight into the reasons behind the occurrence of intersection crashes rather than to simply examine their outcomes.

Domestic and international urban road traffic safety related theories firstly be researched, and then the description of the forecast is the basis for early precaution is be explained, which is based on the research of precaution theory. And make the urban road intersections as the research target to study the status of the intersection's traffic safety, get a conclusion that the pedestrians, left turning vehicles, the type of control, traffic and other factors have a greater impact for intersection traffic safety conditions, build the intersection traffic safety warning indicator system. The key core technology of the car road cooperative technology is be researched, the model which is built in this paper be determined as data prediction model which is belonged to the traffic information processing module internal of the car road cooperative system. Construct the early warning model that...
based on the car road cooperative technology, and the input and output parameters of the model then be determined, evaluation index which is used to analysis the reasonableness of the model and accuracy of the prediction results. Do the model simulation experiment which is combined with calculating examples, do the comparative analysis of the simulation experiment results. The calculating results show that the model which is built in this paper has higher accuracy than the traditional model, by calculating evaluation index such as the model correlation coefficient, that the model be built in the paper can be used as the warning model which is based on the condition of the car road cooperative technology.

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