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Research on Network Model of Transportation System Based on Data Mining and Its Invulnerability

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Abstract: In recent years, in order to alleviate the traffic pressure in urban areas, improve traffic congestion and facilitate people's travel, a large number of urban rail transit projects have been started in various regions. Urban rail transit has the advantages of environmental protection, strong transportation capacity, open transportation speed and stable transportation frequency. It is the main development direction of urban transportation system in the future. In order to improve the operation efficiency of urban rail transit system, most areas adopt the basic mode of network layout, and each node in the network is closely connected, so as to realize the overall improvement of transportation capacity. In order to ensure the security and stability of the network system, it is necessary to strengthen the research on the survivability of network cascading failure to avoid the failure problem affecting the normal operation. The application of data warehouse and data mining technology is an important way to realize the sharing and comprehensive utilization of information resources in intelligent transportation system. Knowledge-based reasoning and machine learning technology in artificial intelligence technology is the key to the intelligence of decision support system, and it is also the key to the success or failure of intelligent decision support system. Data mining is in the influence space of intelligent decision support system and is responsible for dealing with the intelligent decision support of logical nature. Therefore, data mining is in the most important position in the whole intelligent decision support system. This paper analyzes the intelligent transportation system with the method of system engineering, puts forward the architecture of the intelligent transportation system, puts forward the implementation method and problem-solving ideas according to the actual situation in China, and puts forward the optimization scheme for the transportation system and sudden events by using the technologies of data mining and artificial intelligence, so as to provide decision support for decision makers and realize the high efficiency and Stable and controllable

1. Introduction

With the huge leaps in domestic social and economic development and the rapid growth of urban population and land scale, urban public transportation systems dominated by ground public transportation are gradually unable to bear the continuous expansion of total travel volume and continuous expansion of travel distance. Demand [1]. Therefore, in order to make up for the shortcomings of the original public transportation system, major cities have gradually accelerated the planning and construction of urban rail transit based on subways. The subsystem network formed by subway lines and the ground public transportation subsystem network are interconnected to form a huge scale. The new urban public transportation complex system [2]. Because urban rail transit has the advantages of fast speed, large volume and low pollution, it can effectively alleviate the problem of urban traffic congestion [3]. As a result, a wave of rail transit construction is emerging in major cities across the country, and the network of rail transit in some cities is gradually forming and moving to the stage of networked operation [4].

The development of urban rail transit system has brought convenience to people's daily travel and alleviated the traffic pressure of the city [5]. On the other hand, with the rapid increase of passenger flow of urban rail transit, its safety is getting lower and lower [6]. As a transport carrier with particularly dense passenger flow, rail transit has the following characteristics: weak protective measures, large passenger flow and high public attention [7]. In case of external malicious damage or system equipment failure during urban rail transit operation, it will lead to very serious consequences, especially under the condition of networked operation, the failure of any node may spread and spread rapidly in the network [8]. This requires the relevant security mechanisms to be very strict and vigorously improve the effectiveness of security measures In case of external malicious damage, system equipment failure during urban rail transit operation, or sudden sharp increase in passenger flow, it will eventually lead to very serious consequences [9]. In the network, the failure of one or a few nodes or connections will lead to the failure of other nodes through the coupling relationship between nodes, resulting in cascade effect, and finally lead to the collapse of some nodes and even the whole network. This phenomenon is called cascade failure [10]. Similarly, there is a similar phenomenon in urban rail transit network. The interruption of operation of nodes or sections in the network will lead to cascade congestion caused by unbearable flow pressure of other nodes [11]. Therefore, in order to ensure the safe and stable operation of urban rail transit, relevant personnel need to strengthen the research on cascade failure and analyze the survivability of network cascade failure, so as to promote the stable operation of urban rail transit system and promote the economic development of urban areas while facilitating people's emergence [12].

2. Analysis of Intelligent Transportation System Based on Data Mining Technology

2.1 Concept and Characteristics of Intelligent Transportation System

Intelligent transportation system effectively and comprehensively applies advanced satellite positioning and navigation technology, computer technology, image and graphics processing technology, sensor technology, information technology, electronic control technology, data communication technology, operational research, artificial intelligence and other high and new technologies to transportation, service, control and vehicle manufacturing [13]. The connection among people, vehicles and roads has been strengthened. With the help of the functions of the system, the drivers know the real-time traffic conditions like the back of their hands, and the managers have a clear picture of the driving conditions of vehicles. The system can adjust the whole traffic system with the strong support of communication facilities and policies and regulations by analyzing and processing the real-time data, so that the whole system is in the best state, and can respond to emergencies in time and solve them in time. The intelligent decision support space is shown in Figure 1.

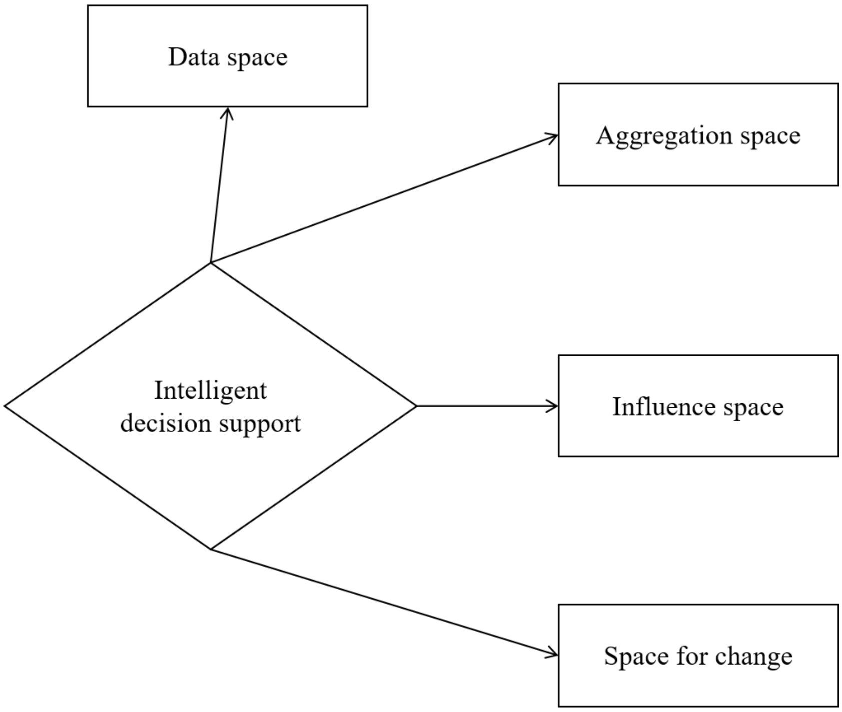

Figure 1. Intelligent decision support space

Intelligent transportation system, as a system, has the generality and particularity of the system. The so-called system is an organic whole with specific performance, which is composed of several parts that interact, depend on each other and can be distinguished from each other. Intelligent transportation system, as a system, has the general characteristics of the system: integrity, relevance, purpose and environmental adaptability. The communication system is very complicated. It is a comprehensive whole composed of many subsystems, such as people, vehicles, roads, facilities, management, environment, etc. Each subsystem is subordinate to this whole, and the whole intelligent transportation system is a subsystem of a larger urban system. The subsystems and units in the intelligent transportation system are organically connected and interacted with each other, and there is a specific interdependent relationship among these subsystems and units. The intelligent transportation system has a specific purpose. That is, it provides necessary material conditions and space activities for people to engage in various activities, and creates conditions for safety, rapidity, high efficiency and comfort. Intelligent transportation system exists in the social environment, is restricted and interfered by the surrounding environment, and is coordinated with the surrounding environment. Intelligent transportation system has the characteristics of self-learning and self-development. Advanced computer and artificial intelligence technology are used to effectively mine historical data, and real-time collected data is used to predict the development trend of the system, thus effectively avoiding it.

2.2 Infrastructure of Intelligent Transportation System

The implementation process of intelligent transportation system is a complex and long work. The construction of intelligent transportation system should be based on the principles of overall planning, systematic design, all-round implementation, and gradual improvement. The data collection components are mainly distributed on the sensors of the road section, such as :Magnetic induction coils, microwave detectors, cameras, etc.. To obtain data such as intersection parking time, number of vehicles, lane occupancy, and vehicle speed. In order to ensure the timely and accurate data transmission, ITS adopts the principle of omni-directional and multi-channel. A data transmission method. The information acquisition components are mainly from electronic display boards, installed at intersections or on both sides of the road, to display real-time traffic jams, bus arrivals, and environmental information. Once the problem is defined, relevant data must be collected. For the actual database system, it contains multiple primitive databases, which is the static database concept mentioned later. For a specific mining task, a higher level of relational database needs to be extracted from it, which is a customized database in practical applications. At present, data mining algorithms are usually based on an extracted two-dimensional relational table. For the discovery task proposed by the user, determine the attribute domain of interest, and perform various data collection operations. Use sampling technology to sample eligible tuples in the database. The data mining process is shown in Figure 2.

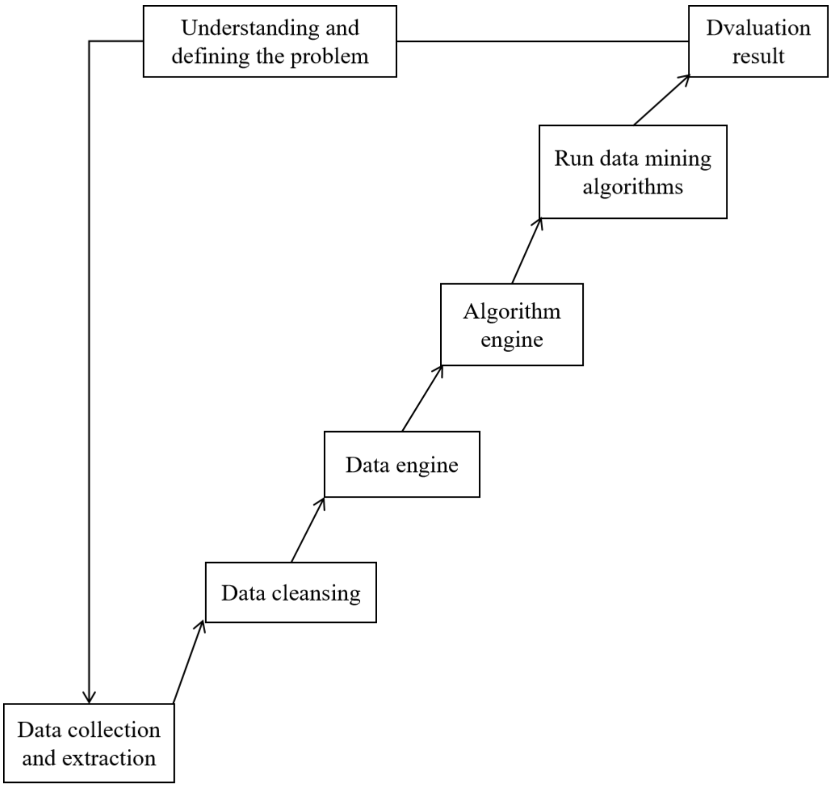

Figure 2. Data mining process

Data is the basis of decision-making and control of the system. Through the analysis and processing of historical and realistic data provided by the traffic system, the goal of intelligent control can be achieved Therefore, establishing a perfect, robust and non redundant data storage system is the key to the success or failure of the system According to the traffic system model, the conceptual model of database is established The conceptual model of database is analyzed, and the data model of transportation network is established by entity relationship This paper analyzes the data flow in the transportation network, determines the entity and relationship set in the database, and establishes the E-R model, which provides a model basis for the establishment of the information network database This paper analyzes the conceptual model of database and establishes the data model of information network with semantic objects Similarly, analyze the data flow in the information network, adopt the object-oriented methodology, determine the semantic objects and their attribute characteristics in the information network, and establish the semantic object model of the transportation network. The intersection flow is controlled by means of timely adjusting the green signal ratio, and the pavement controller is used to clean the pavement in time, especially the pavement control of overpass. Under bad weather conditions, overpass is the main bottleneck of urban traffic congestion Therefore, it is very important to clean the pavement in time According to the analysis results of collected data and the display of monitor images, it can respond to emergencies in time

3. Study on the Cascading Failure and Invulnerability of Urban Rail Transit Network

3.1 Cascade Failure Basic Model

Urban transportation network is an important carrier of all transportation activities in a city, and it is also a key material basis for urban transportation activities to function and depend on. There are load exchanges between different nodes in the urban transportation network and between the external environment. In the open exchange process, it is inevitable to be disturbed by the system inside and outside the system. In some areas, the number of network nodes in the urban rail transit system is insufficient, and the number of edges in the network is insufficient. Once a node in the network system fails, other paths that can play a role are seriously insufficient, and the failed nodes cannot be repaired in time. At the same time, the network cascading failure model needs to fully consider the side weight time factor. The transit time of the shortest route is much lower than the transit time of the alternative route. For this reason, the shortest route needs to be selected first in the process of route selection. In the process of traffic flow distribution, transfer stations and ordinary stations need to adopt a differentiated distribution method, focusing on the analysis of the time and number of transfers, and weighting is required for specific transfer nodes. In actual operation, the transfer station can be transformed into a different virtualized station, and the transfer side can be used to connect the stations. The processing in the transfer station network model is shown in Figure 3.

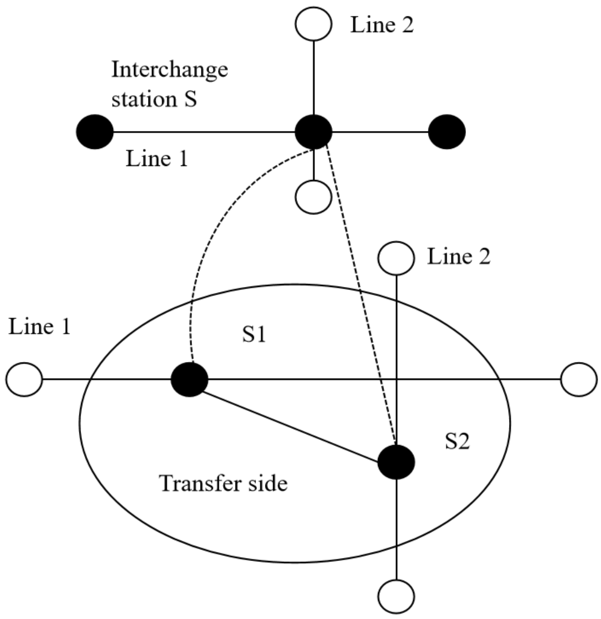

Figure 3. Processing of transfer station in network model

If there is a failed node in the urban rail transit network, the network topology will change significantly, and passengers need to re-select the shortest route, which will also lead to the increase of traffic pressure at the node. If the traffic flow reaches the limit of the node, it will cause serious failure problems at the node position, which will lead to the occurrence of traffic congestion, the impedance at the node position will increase, and the edge weight will increase synchronously, but the transportation capacity of the node will not be completely lost. In actual processing, the problem that the capacity of other nodes is lower than the flow caused by node failure needs to increase the node impedance, which cannot be directly deleted. Because of node failure caused by equipment failure and external factors, all adjacent nodes need to be deleted. The passenger flow of each section and each node of urban rail transit together constitutes the overall load of urban rail transit network. In practical analysis, it can be assumed that passengers will choose the shortest route between the destination and the starting point, and the specific traffic volume of a node can be obtained after the initial flow and route allocation. The passenger flow distribution capacity of urban rail transit stations will be limited by factors such as pre-planning and design, construction cost, etc. In the process of passenger flow forecast, it is necessary to reserve appropriate space and determine the specific scale of stations according to actual demand. In the process of cascading failure calculation, it is necessary to first determine the weight of each edge and establish an undirected weighted network model. Finding the shortest path between any nodes is mainly based on Floyd algorithm. Traffic demand is allocated to each node of the network according to all-or-nothing mode, and initial flow and initial capacity are determined. Delete the failed nodes and adjacent nodes in the network in time to form a brand-new urban rail transit network, and calculate the flow and the shortest path here, and analyze the relationship between the flow and capacity of each node.

3.2 Cascade Failure Survivability Assessment

After cascading failure occurs in urban rail transit network nodes, the ratio of normal nodes to initial nodes is effective node ratio, which can scientifically analyze the overall scale of network failure and evaluate the impact of cascading failure on urban rail transit network. The higher the effective node ratio, the stronger the anti-destruction performance of urban rail transit network cascading failure. The index of network efficiency can be used to measure the damage caused by the failure of the urban rail transit network. The reciprocal of the distance between two nodes in the rail transit network is the network efficiency. There are many nodes in the urban rail transit network, and the average value of the efficiency of all nodes represents the overall efficiency of the network. In case of cascading failure, the ratio of the efficiency in the cascading failure state to that in the initial state can be used to analyze the survivability. The higher the numerical value, the stronger the survivability.

Combined with the process description of cascading failure and the built invulnerability measure, the following invulnerability measure model of cascading failure is established:

(1) In the urban transportation network, the traffic load of node i is l_i, its maximum capacity is $C_i, i \in 1,2,\Lambda\ ,m$, let $C_i = \alpha \cdot l_i^0, l_i^0$ be the traffic load at the initial moment of node i, and α is the node capacity coefficient (representing the node's ability to handle additional load, and $\alpha > 1$) .

(2) A certain node in the urban transportation network is attacked at a certain moment, and the attacked node will distribute its original load to neighboring nodes. According to existing research, the load distribution formula is:

$$l_j^{new} = l_j + \frac{c_j - l_j}{\sum_{i \in \Gamma_j} c_1 - l_i} \cdot l_j \quad (1)$$

Where l_i represents the load of the attacked node; l_j represents the existing load of a neighboring node j of node i; l_j^{new} represents the new load of a neighboring node j of node i; c_j represents the maximum value of a neighboring node j of node i Capacity; Γ_j represents the set of neighboring nodes of node j.

(3) Let set M be the set of non-failed nodes, and N be the set of failed nodes. After the node load is updated, the failure judgment rule is:

$$\begin{cases} k \in M, l_k^{new} < C_k \\ k \in N, l_k^{new} \geq C_k \end{cases} \quad (2)$$

For the nodes in the set N, the load needs to be redistributed again, and the excess load is distributed to the neighboring nodes that have not failed. The distribution formula is:

$$l_k^{new} = l_k + \frac{c_k - l_k}{\sum_{i \in \Gamma_k} (c_1 - l_1)} \cdot (l_j - c_j) \quad (3)$$

Among them, k represents the neighboring node of node j.

(4) Nodes in the network that do not belong to the original set N, judge whether their load exceeds the maximum capacity, if it exceeds, they belong to the set N, and go to step (3); if it does not exceed, it belongs to the set M.

(5) When the set does not change from M, N, the cascade failure ends; the network connection rate and the number of diffusion times are used to evaluate the survivability of the network cascade failure

4. Conclusions

This paper presents the architecture, infrastructure and decision support system design of intelligent transportation Based on the analysis and processing of historical data and real-time data, this paper puts forward the basic idea and framework of dealing with general problems and sudden disasters in transportation system combined with the experience of decision-makers This paper mainly makes a more in-depth research and Discussion on the construction of database, flow prediction and control in intelligent transportation system. In the future research work, the methods in this paper will be combined with practical projects, gradually in-depth research, constantly improve the algorithm, and further improve the performance of the system through the combination of theory and practice It can be seen from the above conclusions that as more and more cities speed up the construction of rail transit, the urban rail system network dominated by subway can improve the overall efficiency and survivability of subway bus composite network to a certain extent, and there is the necessity and possibility of coordinated development between rail transit subsystem and ground bus subsystem; At the same time, it is also necessary to formulate corresponding composite network emergency linkage mechanism for intentional attacks, so as to effectively deal with sudden network failure.

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If any, should be placed before the references section without numbering.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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