The Use of Artificial Intelligence in the Construction of Operation Safety Early Warning Management System of Urban Rail Transit

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Abstract: In order to reduce the risk of safety management of urban rail transit (URRT) and improve the safety early warning of URRT, artificial intelligence (AI) is used to construct the early warning management system of URRT. Firstly, the four factors that affect the safety of URRT are discussed, the URRT system is divided into several modules, and the functions of each module are introduced. Secondly, the safety early warning analysis module is designed based on neural network technology to make it have the ability of safety early warning. Finally, the security prediction system is tested. The results show that the overall prediction error of probabilistic neural network algorithm used is less than 5%, and the classification accuracy of PNN is about 50%, which can achieve excellent prediction of data. The safety early warning system is used to predict the passenger flow of a station, and compared with the actual passenger flow, the prediction model has good prediction accuracy and credibility. Therefore, the safety early warning management system of URRT designed can meet the needs of practical application. This paper provides a reference for the safety management of URRT.

1. Introduction
With the boom of urban transit technologies, urban transit systems are increasing, which provides more traveling options for the citizens, but meanwhile leads to more traffic safety problems. Therefore, it is necessary to create an urban transit traffic safety early-warning management system to prevent safety accidents and address emergencies, and realize monitoring and prediction of safety conditions of stations. Emerging technologies like big data and artificial intelligence (AI) can help realize optimal allocation of resources and provide a basis for decision-making of urban transit management. Based on the massive data in cities and the AI technology, this study aims to create a smart traffic management system to realize safe and efficient management of the urban transit system [1].

Li et al. (2018) applied the text mining method to safety risk management. By word frequency analysis and clustering analysis, they identified 13 safety risks from 156 traffic accident reports, built an accident description model consisting of indirect safety risks and direct safety risks, to measure the risks of accidents [2]. Pu et al. (2018) put forward the concept of controlled bottleneck to solve the problem of overcrowding and the resulting potential safety risks in stations of urban transit systems. By using controlled bottlenecks like safety examining machines and automatic ticketing machines, they could control the number of passengers within a proper range. The result shows that the controlled bottlenecks had good performance in controlling the number of passengers [3].

To improve the safety of urban transit, this paper designed an urban transit safety early warning management system based on AI technologies to realize monitoring and forecast of safety of urban transit systems. The system was also tested by certain sets of metrics.
2. Methods
Urban island traffic operation safety and early-warning system can monitor and predict the operation conditions of the transit system and provide emergency plans when accidents occur. There are many types of accidents in the operation of urban transit systems, and they are caused by different factors that usually involve four aspects — personnel, devices, operation environment and safety management, which interact with each other. These factors present temporal and spatial changes, and changes in one aspect may lead to a traffic accident. Therefore, there should be early warning for any of these factors to address existing problems in time and preclude traffic accidents [4, 5]. Figure 1 shows the interactions of contributing factors to urban transit traffic accidents.

Urban transit traffic safety early warning system realizes monitoring and forecast of the transit system operations based on the static and dynamic data of the traffic networks. The static data refer to the information on the transit station staff, vehicles, stations; dynamic data refer to information that changes with time, such as the passenger flow, equipment faults, the vehicle shifts, etc. The early warning system processes information on the station, transit lines and transit networks, and outputs early-warning signals to determine the current safety states.

In this study, an urban transit traffic operation management system was designed consisting of five modules — data collection and processing, information queries, safety early-warning analysis, expert decision-making, and emergency warning, to realize monitoring and early warning of the operations of the urban transit system, as shown in Figure 2.
Figure 2. Structure of the safety early-warning system

(1) The module of data collection and processing serves to collect and input dynamic data, indicators, early-warning thresholds and other data. It collects and stores the single early warning indicators, and pre-process the data of different types and scales in different forms. The safety early warning on the station layer is taken as the foundation of the indicator system, which, together with early-warning indicators on the traffic routes, passenger flow and traffic command, constitute a complete early-warning indicator system. The weights of these indicators in different routes and networks are considered to perform safety early warning analysis, thereby acquiring the safety conditions of the urban transit system.

(2) The information query module can be used by the station staff and administrators to inquire the static and dynamic single early warning indicators including the crowdedness and passenger flow of the station, as well as the comprehensive indicators including the station, routes and networks. This module also includes a basic information database that involves historical traffic safety events, layout of the stations, and the station staff information, and realizes statistical analysis and graphic presentation of the operations of the urban transit system by way of the GIS technology.

(3) The safety early warning analysis module is the core of the system and realizes safety early warning based on single indicators and comprehensive indicators using neural networks. Single early-warning indicator early warning realizes safety early warning by the single threshold values in the input data of the urban transit system. The comprehensive indicators are integration of single parameters merged by the Dempster/Shafer (DS) evidence theory and information entropy. It does not need massive data training, and with the weights of data, it avoids subjectivity in expert decision-making, and the weights can be dynamically adjusted by the changes in data. The comprehensive indicator system uses the probabilistic neural network (PNN) to realize safety early warning of the transit system. The station early warning indicator, the equipment early warning indicator, the passenger flow early warning indicator and command early warning indicator are taken as the input layer, and the output is the early warning result. The neural network model of the urban transit traffic safety early warning system is shown in Figure 3.
Figure 3. Structure of the probabilistic neural network model

By weighted sum of different routes and comprehensive early warning of the road network in the urban transit system, the early warning function for the whole transit system can be obtained. The urban transit traffic safety early warning analysis model designed in this paper is realized by the steps described in Figure 4.

Figure 4. Safety early warning analysis processes

(4) The expert decision-making module can provide emergency strategies in response to safety early warning signals. The module consists of basic information of experts in different fields, the thresholds of early warning indicators, the experts’ reviews of different emergency states and emergency strategies of different early warning levels. Experts in different fields will analyze and evaluate different levels of early warning indicators to obtain basic training data for the safety early warning module, and combine information technology with strategies provided by experts in response to different levels of emergencies.

(5) The emergency early warning processing module serves to manage emergency plans, release of early warning information and manage emergency materials. Management of emergency plans refers to the process of collecting and sorting experts’ experience and emergency response measures into a database, and then identifying corresponding emergency measures as per the level of emergency; then, it releases the early warning information on the Internet to grasp the safety conditions of different stations, routes and networks, manages the storage and dispatch of emergency materials.
3. Results and discussion

3.1 Performance test of the probability neural network

The PNN proposed in this paper was tested regarding its accuracy. The dataset was used as the training set, and ten groups of data were used to evaluate the forecast errors, as shown in Figure 5.

As Figure 5 shows, the model had an overall error less than 5%, and the minimum error was below 1.5%; the maximums showed large fluctuations and had little impact on the overall error rate. Therefore, the trained PNN performs well in forecast of real data and the error falls within an acceptable range.

In this paper, the PNN and the radial basis function (RBF) as well as the general regression neural network (GRNN) were compared to test their classification accuracy. The models were trained on the same set of data and six groups of data were selected for experiments, as shown in Figure 6.

As Figure 6 shows, the RBF model achieved an accuracy less than 25%, which showed poor performance, and the PNN model outperformed the GRNN model and achieved an accuracy above 50%, indicating a good performance. Therefore, the PNN model had better computation performance than traditional models.

3.2 Real-world application of urban transit safety early warning management system

The proposed model was applied for forecast of passenger flows of a metro station within 24 h, and the result is shown in Figure 7.
As Figure 7 shows, the passenger flow forecasted by the proposed system is largely consistent with the real passenger flow data. Before 14:00, the forecast data and the real data show little difference, but in peak hours, the forecast value is generally higher than the actual value. The reason may be that the training data are not sufficient and undermine the accuracy of the model. In general, the proposed model shows good accuracy and confidence.

To sum up, testing and comparison of the PNN model have shown that the PNN algorithm can achieve good accuracy and has good computation performance, and meets the requirements of the designed system. Real-world application tests show that the proposed system can achieve high accuracy and confidence in forecasting of the urban transit operations.

4. Conclusions
To improve safety of the urban transit system, this paper designed an urban transit traffic safety early warning management system using AI technologies and detailed its functional modules. Firstly, the factors affecting the safety of urban transit systems were concluded, and corresponding modules were established; secondly, this paper designed the safety early warning analysis system based on neural networks to realize monitoring and forecast of traffic conditions; last, the safety early warning system was tested. The result shows that the designed system has shown good accuracy and confidence when applied to real-world scenarios. The major limitation of the study is that the training data are not sufficient and lead to a low accuracy of the forecast result, which is expected to improve in our future works.

References
[1] Gao H, Liu S, Cao G, et al. Big Data Analysis of Beijing Urban Rail Transit Fares Based on Passenger Flow. IEEE Access, 2020, 8, pp. 80049-80062.
[2] Li J, Wang J, Xu N, et al. Importance degree research of safety risk management processes of urban rail transit based on text mining method. Information, 2018, 9(2), pp. 26.
[3] Pu Y, Xu H, Nie X. Study on the bottleneck of urban rail transit station based on the operation safety. IOP Conference Series Materials ence and Engineering, 2018, 392(6), pp. 62140.
[4] Lei Qian, Weiteng Zhou, Baoming Han. Visual analysis of emergency data in urban rail transit operations. Journal of Railway Science and Engineering, 2020, 17(4), pp. 1025-1035.
[5] Xinhua Li, Junhui Li. Research on the Operational Safety Early Warning System of Urban Rail Transit. Modern Urban Rail Transit, 2018, (10), pp. 58-62.