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ORIGINAL ARTICLE

Research and Implementation of Assistant Decision-making System for Emergency Handling of Traffic Accidents in Urban Rail Transit

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Abstract: The main research content of this paper is an assistant decision-making system for emergency handling of traffic accidents in urban rail. The system is to further improve the ability of rail transit control departments to deal with emergencies through its design and application. The system can automatically judge the accident parameters and analyze the main information of the accident during the application process to put forward a systematic solution to traffic accidents, and thus reasonably arranging for urban rail train dispatching during the accident. Besides, combined with the train's normal operation, the system will collect train emergency prediction data during its application, and visualize the predicted information to provide references for the adjustment of emergency plans, further reducing possible hazards. Meanwhile, this article demonstrates the system's application with the combination of metro line 3, which ends with a satisfying result. It can be considered that the designed assistant decision-making system has practical value and can adjust train operation plans and predict passenger flow.

Keywords: Rail Transit; Train Operation; Passenger Flow Forecast; System Development

Introduction

In recent years, with the gradual acceleration of China's urbanization construction process, the number of urban rail transit lines are also correspondingly increasing. The quantity and quality of rail transit have become a basic measurement of urban construction. Nowadays, with the technology development of the internet and information, rail transit has gradually become networked. How to apply the existing technology to improve the safety and stability of rail train operation is one of the issues that must be considered and solved at present. This paper, through the following research, provides and designs a relatively complete emergency decision-making aid system to further improve the safety of rail transit with the reasonable application of the technology and ensure the safety of passengers' lives and property.

1. Design of assistant decision-making system for emergency handling of traffic accidents

Based on the basic situation of urban rail transit, an emergency auxiliary system for urban rail transit is set up, which aims to further improve the operation effect and quality of urban rail transit and ensure the personal safety of citizens.

1.1 Design objectives

The ultimate goal of this design can be summarized as follows:

(1) The operator can immediately obtain a fault treatment plan by inputting fault information, and make appropriate adjustments to the train operation state when an accident occurs to ensure the state of train operation.

(2) With the analyzing of and dealing with accident situations, the passenger flow of trains can be analyzed,

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summarized and predicted, which can be displayed through the curve network diagram. The relevant management personnel can therefore more intuitively understand the passenger flow of the train, and be able to carry out targeted adjustment accordingly on the rail transit operation according to the passenger flow.

1.2 Design of system structure

1.2.1 Design of system architecture

In the whole system architecture design, the display layer, logic layer and data layer will be designed according to the actual use requirements. These three layers are independent and are at the same time related to each other, which fully ensures the expansibility and applicability of the whole system. The specific structure is shown in Figure 1.

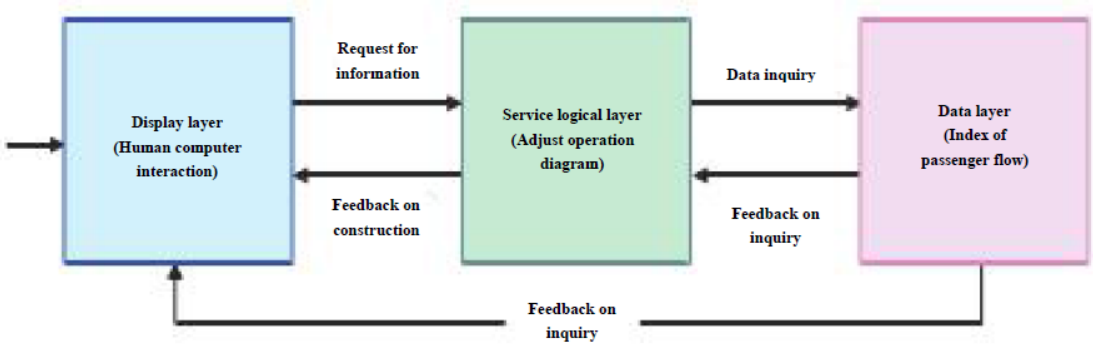

Figure 1. Three-layer architecture diagram of the system

1.2.2 Logic function structure design of the system

The structural design of logical functions is considered according to the basic infrastructure. The authors believe that the basic logical functions of the three-tier architecture have certain circularity and hierarchy. The specific content is shown in Figure 2.

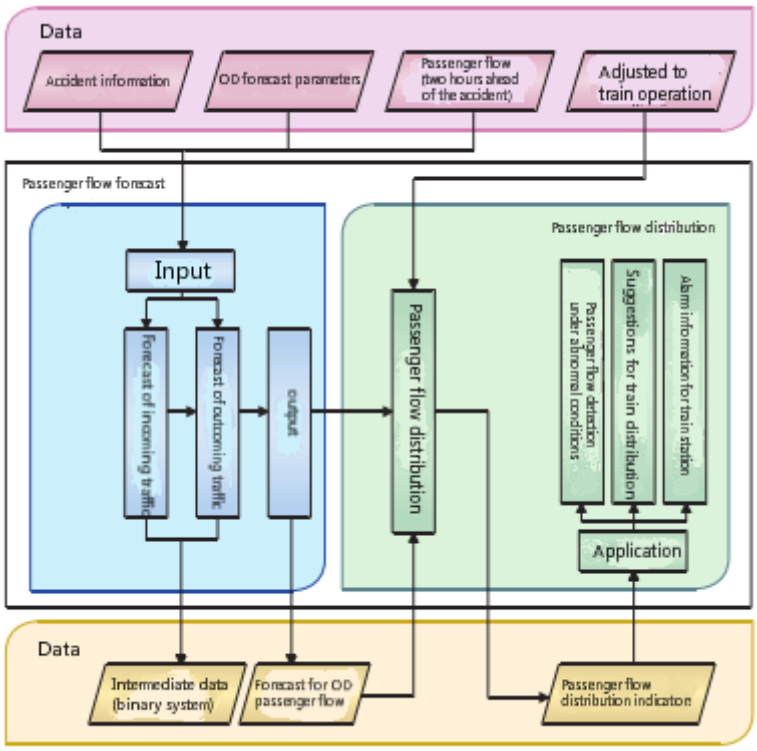

Figure 2. Logic function structure diagram

1.3 System data interface

According to application requirements, it interfaces with AFC system and ATS system.

2. System implementation

(1) Train delay. According to the accessed real-time ATS data, authors compare the system and the actual arrival time of each train at the station with the arrival time of the planned operation diagram. If the actual arrival time of a certain train exceeds the planned arrival time by two minutes or more, the system will automatically trigger a traffic emergency.

(2) Train interval. According to the real-time ATS, the system continuously calculates the actual running interval between every two trains. Once the running interval between two trains exceeds 1.5 times of the normal interval, the system will automatically trigger a traffic emergency.

3. Key technologies

Key technologies applied in the system design includes machine learning technology, passenger flow distribution technology and other necessary transformation technologies and algorithms.

3.1 Technology of train operation plan adjustment based on machine learning

The basic technology mainly used in this system is machine learning technology. Under this technical background, this system will record and analyze the previous train operation information and operation status, and learn the dispatcher's operation behavior as well as operation experience. The train operation plan of the system can therefore be more accurate and more in line with human operation ideas.

3.1.1 Machine learning technology

The theoretical basis of machine learning technology is physiology and cognitive science, which enables machines to understand human's behaviors and mechanisms, and then imitate them by establishing learning calculation models and cognitive program models. During the design, the system will collect and analyze the previous train operation information from the track department and the field investigation information. The system will introduce non-linear analysis method and function analysis method in the analysis process to summarize the dispatching experience of the operators and record it, which includes the following five contents, namely, train shutdown, additional open, downgrade, turn-back and train impounding.

3.1.2 Handling principle of emergency train based on machine learning

After the system completes machine learning, it will obtain a large number of train dispatching result. Base on this, as long as train parking and treatment principles of other accidents are set, the system can work normally and give treatment methods with more details. For example, some common contents are as follows: the system can maintain the established train operation diagram before the accident occurs, and then adjust the whole line of the train timely according to the time and accident conditions to keep the train running normally; the system should ensure that train impounding is the optimal measure among the overall commands, followed by the train downgrade, etc. When a sudden accident occurs, train backlogs may occur in 20 minutes. If trains in the other line are not affected at this time, they can turn back ahead of time. The original operation state of the train will be recovered.

3.2 Dispatching technology of passenger flow based on aggregate model

In traffic operation planning, in order to ensure the analysis effect and quality, normal practice is to divide a whole object and region into several different small regions, then conduct systematic analysis and establish models on these regions. Then the samples are enlarged on the basis of the model establishment, the process of which requires aggregation. The results obtained from each region are regarded as an aggregate data, which will be further established to an aggregate model.

In the process of designing the system in this paper, the local distance between the starting and ending points of the train will be obtained based on the K short-circuit algorithm, as well as the passenger flow under the current situation. Accordingly, the passenger flow and route will be arranged to obtain the output index of the system passenger flow.

4. Case studies

On the basis of system design, this paper takes the train operation of Chengdu Metro Line 3 as an example for application analysis. First of all, it is assumed that there is a train accident on the line between Hongxing Bridge and Chengdu Second People's Hospital at 8:15 a.m. (morning peak) some day, with an accident time of 10 minutes. After application of the system, the following results are obtained:

After the accident occurs, open the fully designed system and switch to the manual accident input interface for information input. Then the system can make the operation plan during the train accident and obtain the train passenger flow information during this period.

In the process of passenger flow forecast, the system can directly display the passenger flow, so that the personnel can obtain the passenger flow according to the displayed interval results, as well as the passenger flow in different time periods by moving the time axis.

5. Conclusion

To sum up, the main research content of this paper is the common emergencies in the daily operation of urban rail transit, from the two perspectives of train operation and passenger flow. In order to ensure sufficient stability and safety of train operation and reasonable train dispatching, an assistant decision-making system for emergency handling of traffic accidents is researched and developed. At present, the main function of the system in application is to provide decision-making for rail train operation and to display passenger flow during the accident period, so as to improve the accident handling quality of the operation department. In the practical application, the advantage and value of the system is to display passenger flow, which provides necessary data reference for later accident treatment.

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