The Design of Intelligent Passenger Organization System (IPOS) for Metro Stations Based on Anylogic

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Abstract—Passenger organization has always been an essential part of China's metro operation and management. Facing the massive passenger flow, stations need to improve their intelligence and automation degree by an appropriate integrated system. Based on the existing Integrated Supervisory Control System (ISCS) and simulation software (Anylogic), this paper designs an Intelligent Passenger Organization System (IPOS) for metro stations. Its primary function includes passenger information acquisition, data processing and computing, visualization management, decision recommendations, and decision response based on interlocking equipment. For this purpose, the logical structure and intelligent algorithms employed are particularly devised. Besides, the structure diagram of information acquisition and application module, the application of Anylogic, the case library's function process are all given by this research. Based on the secondary development of Anylogic and existing technologies like video recognition, the IPOS is supposed to improve the response speed and address capacity in the face of emergent passenger flow of metro stations.

1. INTRODUCTION

With the rapid development of China's social economy and urban modernization, urban rail transit has become the focus of infrastructure construction. Because of its characteristics like safe, fast, punctual, comfortable, large carrier capacity, and environment-friendly, urban railway transit undertakes nearly 40% to 50% of the city's passenger transport. By the end of 2019, China's mainland had 40 metro cities and 208 urban rail transit lines, with a total of 6736.2 kilometers. In terms of the passenger flow of rail transit, China's total passenger volume in 2019 was about 23.71 billion, an increase of 2.64 billion over 2018. Fig.1 shows the development of urban rail transit in key cities in China. The chroma bar of passenger flow intensity ranges from [0.5,1.8], and the unit is 10,000 person-time/km.

It is expected that by 2023, the mileage of Beijing, Guangzhou, Shanghai, and Chengdu will range from 800 to 1000 kilometers, facilitating more citizens. A large number of passengers will be a significant challenge to the subway operation. In the face of large-scale passenger flow, existing facilities and equipment are already somewhat stretched, and it is challenging to keep pace with the development of urban rail transit. It has become an urgent and hot issue that to improve stations'
organizing ability of passengers and intelligent management levels while building the subway on a large scale.

By accumulating experience and scientific research, passenger stations' design and operation are becoming perfect. Still, there are some particular circumstances such as sudden large passenger flow, equipment renewal or failure, change of flow line or congestion, etc. In the face of a complex operational management system, it is difficult to rely on human experience and means to solve effectively. It might cause many stranded passengers to affect social order, bring economic losses to the operating company, or even occur safety accidents and so on. Therefore, at present and in the future, it is necessary to design and develop intelligent operation and management systems for a station to realize real-time information collection, visual perspective, reliable decision-making ability, and quick response speed. The primary significance of the design of the system in this paper is as follows:

1. Improve the passenger station's function, improve the utilization level of various equipment, ensure the passenger station's traffic order, improve the level of operation and management of the passenger station.

2. Improving the emergency response ability of passenger station through linkage, to realize the rapid, scientific, efficient, and accurate emergency command of passenger organization, and reduce the loss caused by sudden events.

3. Combined with the organization of train operation in the future, it is helpful to adjust passenger flow dynamically and accurately, improve operation efficiency of urban rail transit, and ensure the operation safety.

Deng X. F. combined with the project of "Deepening Research on Operation Management and Intelligent Service Technology of Large Passenger Station", one of the key scientific research projects of the Ministry of Railways, to deal with the sudden change of station complex system. He studied how to use Anylogic and case-based reasoning algorithms to establish passenger organization decision-making systems in large passenger stations (Deng Xinfeng, 2011).

From the perspective of improving the efficiency of the urban rail transit system, Shanghai Shen Tong Metro Group Co., Ltd puts forward a series of operation and organization methods suitable for the ISSC system of rail transit based on the practice of subway operation and management (Shanghai Shentong Rail Transit Research and Consulting Co., Ltd., 2009). Subsequently, to further build an efficient, safe, and intelligent transportation and management system, to adapt to the development direction of fully automated operation line (UTO), Shèn Tong Group United with Nan Rui Group designed and developed the site-oriented intelligent platform—Smart Operation & Management (SOM) for Shanghai Line 10 (Xu Chao, 2019).

Yuan Wei intensely studied the monitoring function and structure of the BAS system. From fire protection, access control, lighting, security, and other subsystem operation, he studied how to achieve the overall linkage and make each subsystem of the system complete the linkage function in an orderly manner (Yuan Wei, 2014).

This paper focuses on the subway station to designs the IPOS. From the angle of metro stations' passenger organization, the research objects are stations with large passenger intensity and condensed structure, so the research results are also useful for the traditional railway stations.

2. KEY TECHNOLOGY ANALYSIS
The Intelligent Passenger Organization System (IPOS) proposed in this paper is a man-machine interaction system that integrates information technology, communication technology, and intelligent technology. It mainly relies on the modern artificial intelligence algorithm and related system software to realize. The key technologies include Video Recognition technology, Anylogic simulation technology, Decision-making Support System (DSS), and Integrated Supervisory Control System (ISCS).
2.1 Video Recognition Technology

Video recognition mainly includes collecting and transmitting front-end video information, medium-term video detection, and back-end analysis and processing. In the passenger station, the video signal is clearly and stably provided by the camera, and the samples are obtained using filtering and image modeling. Finally, the traffic is extracted by the intelligent video analysis module based on artificial intelligence and pattern recognition algorithm, and the report forms are obtained afterward. Because the moving objects are simply people, it is unnecessary to classify objects and set up a vast pattern recognition database. In China, the accuracy of this technique has reached more than 90%.

2.2 Anylogic Simulation Technology

Anylogic is a complex system simulation software for traffic simulation, which consists of a basic simulation platform, pedestrian storehouse, enterprise database, etc. Pedestrian simulation mainly depends on its pedestrian storehouse. The core algorithm is the social force model, which provides various modeling methods and is the only commercial simulation tool for innovative hybrid modeling. The main advantages of selecting Anylogic as the embedded simulation software of the system are:

1. Anylogic has many modeling methods, which can more accurately model and capture more complex events and adjust and combine with specific problems in real-time.
2. The modeling process is quick and straightforward. It has excellent analysis components and optimization tools, which can be used directly in the modeling environment.
3. The visual effect of pedestrian simulation is decent. It can show passengers' density through a thermal graph, support the drawing and automatic generation of the 3D model, and generate a dynamic graph.
4. Anylogic can work with other software and custom modules written in Java or other languages, support agent-based modeling and secondary development, to facilitate integration or embedding.

2.3 Decision-making Support System (DSS)

DSS is a computer application system that assists decision-makers in making semi-structured or unstructured decisions through human-computer interaction through data, models, and knowledge. It provides decision-makers with the environment to analyze problems, builds models, simulates decision-making processes, and schemes. It also invokes various information resources and analysis tools to help decision-makers improve their decision-making level and quality. It has been applied in field management, automatic operation, maintenance, emergency prevention, etc. Especially under the station's condition, the adjustment means in passenger organization work are limited, which is more favorable for the system to give scientific and reasonable decision-making advice through the operation in time.

2.4 Integrated Supervisory Control System (ISCS)

ISCS is an extensive computer integrated system based on modern computer technology, network technology, automation technology, and information technology. It can realize information sharing, monitor, and link each subsystem under its jurisdiction. It mainly serves the rail transit dispatcher and equipment maintenance personnel. At present, the system has been installed in the subway in Beijing, Shanghai, Guangzhou, Shenzhen, and other places in China.

The integrated scheme with power and environmental control dispatcher as the core is adopted at home, while the integrated scheme with the train operation command as the core is adopted abroad. The latter is more advanced in technology, such as the New York Metro, Tokyo Metro, and Paris Metro. The system designed in this paper will be based on a fully integrated comprehensive monitoring scheme, and several subsystems will be added to the traditional subsystem to realize the corresponding functions. The conventional integration pattern can be seen in Table 1.
TABLE 1. CURRENT STATUS OF ISCS INTEGRATION

| Name   | Station-level depth integration | Station-level integration | Station-level interconnection | Center-level depth integration | Center-level integration | Center-level interconnection |
|--------|--------------------------------|----------------------------|-------------------------------|------------------------------|-------------------------|-----------------------------|
| PSCADA | ✓                              | ✓                          |                               | ✓                            | ✓                       |                             |
| BAS    | ✓                              | ✓                          |                               |                             |                         |                             |
| PSD    | ✓                              | ✓                          |                               |                             | ✓                       |                             |
| CCTV   | ✓                              | ✓                          |                               |                             |                         |                             |
| PA     | ✓                              | ✓                          |                               |                             |                         |                             |
| PIS    | ✓                              | ✓                          |                               |                             |                         | ✓                           |
| FAS    | ✓                              | ✓                          |                               |                             | ✓                       |                             |
| ACS    | ✓                              | ✓                          |                               |                             | ✓                       |                             |
| ATS    | ✓                              | ✓                          |                               |                             | ✓                       |                             |
| AFC    | ✓                              | ✓                          |                               | ✓                            |                         |                             |
| CLK    | ✓                              | ✓                          |                               |                             | ✓                       | ✓                           |
| RC     | ✓                              | ✓                          |                               |                             | ✓                       | ✓                           |
| CCAS   | ✓                              | ✓                          |                               | ✓                            | ✓                       | ✓                           |
| OA     | ✓                              | ✓                          |                               | ✓                            | ✓                       | ✓                           |

Note: PSCADA represent Power Supervision Control and Data Acquisition; BAS represent Building Automation System; PSD represent Platform Screen Doors; CCTV represents Closed-Circuit Television; PA represent Public-address System; PIS represent Passenger Information System; FAS represent Fire Alarm System; ACS represent Access control system; ATS represent Automatic Train Supervision; AFC represent Automatic Fare Collection; CLK represents Clock; RC represent Remote Control; CCAS represent Communication Centralized Alarm System; OA represent Office Automation.

3. THE STRUCTURAL DESIGN OF IPOS

The Intelligent Passenger Organization System (IPOS) designed in this paper mainly consists of four functional modules:

1. Information Acquisition Module: It inherited most of the structure and functions of ISCS, designed two new functions autonomously, and has strengthened the environmental control module. One is to increase the monitoring of travel service equipment; the second is to add weather information in BAS system.

2. Visualization Module (including data processing): the video recognition technology and Anylogic simulation technology are used to integrate the monitoring function of ISCS to realize the all-round grasp of the station. The emphasis is to visualize pedestrian features and lay a foundation for decision-making.

3. Decision-making Support Module: mainly rely on the agent modeling and visualization function of Anylogic, combined with mathematical model and algorithm, the optimization recommendations are given based on the database, cloud computing, and other technologies. See the next chapter for specific implementation methods.

4. Joint Adjustment & Linkage Module: integration of all the station equipment, automatic computer control, the realization of emergency or adjustment of the rapid response and implementation of the program, reduce the workload of personnel.

Fig.1 mainly shows the implementation principle and logic of module 1 and 2. Module 3 and 4 will be reflected in the function introduction.

The following is an explanation of some content in Fig.1:

1. The passengers' distribution refers to how much flow is undertaken by different station entrances and exits.

2. The information collection of the outdoor weather is added to the BAS module because it can affect passengers' travel mode choice, influencing the passenger flow. Besides, on the rainy days, the station needs to strengthen the anti-skid measures as well as to provide the plastic bag for carrying an umbrella.

3. The passenger's diameter is the effective diameter that includes the carry-on luggage, which is obtained from the algorithm.

4. The travel service facility and equipment monitoring system is the subsystem of the ISCS mentioned before, which needs to be added.
5. Special situation information can't be collected through equipment, which needs manual communication and input information to the computer system manually;

6. The visualization of the exceptional cases in the diagram is the opening of various emergency modes actually, and the concrete visualization will be displayed in Anylogic.

Figure 1. Structure diagram of information acquisition and application module.
4. THE FUNCTION INTRODUCTION OF IPOS

Anylogic is chosen as the core module of the IPOS system because of its expansibility of secondary development. It is embedded in the system through Java language.

After the environment modeling and behavior modeling, the data of the information collection module and the data processing module are applied to the simulation in the process of operation, and the visualized 2D and 3D images and data results are obtained. Then, the Case Base is retrieved based on the index. Finally, auxiliary decision-making advice is given.

Fig.2 shows how the above functions are implemented. Based on the Fig.2, further explanations and functional introductions are given here:

1. In the optimization method of equipment in the above Fig.2, the second one refers to elevators' speed, security inspection machines, and ticket vending machines. The third one refers to the direction of escalator and gate machine; the fifth one can adjust the quantity of equipment opening, or the number of equipment placement can also be adjusted; except to station design adjustment, or emergency blocks the flow line, generally don't change the streamline.
2. The IPOS system proposed in this paper is based on a number of simulation cases and evaluation indicators to provide decision support. In the design or pre-operation period, Anylogic is used to simulate various passenger flow rate, faults, emergencies, and so on, combined with the evaluation index, appropriate auxiliary decision-making recommendations are given (these suggestions can be provided by model algorithm or experienced experts). The above simulation results and decision recommendations are stored as cases, so the Case Base is established. In the actual operation, through comparing the actual situation and the case, the system can automatically give out the decision-making suggestion, or in the absence of similar cases, then store the current situation as a new case. The specific steps of contrastive reasoning are as follows, which is called the 4R Model (Fig.3):

The 4R Model: Step I: Case retrieval. According to the index description of the target case, the most similar case to the given problem is retrieved in the case base. Step II: Case reuse. Re-attempt to solve the target case with this case's solutions; Step III: Case correction. If the retrieved case reuse does not adapt to the solution of the target case, then the case is modified to adapt to the solution of the target case; Step IV: Case store. The process of storing target cases and solutions as a new case, storing new cases in a case library for future use.

Figure 3. Case base function process.

5. CONCLUSIONS
1. The main work of this paper is to design the IPOS based on the ISCS, Anylogic simulation technology and intelligent algorithm. The specific results are as follows:

2. The paper analyzes the problem that the means and ability of China's passenger station to organize passengers is not enough, the paper mainly based on the development trend of the subway, and puts forward the important significance of the development of the IPOS.

3. The functional characteristics and limitations of the current metro station ISCS are deeply studied. Based on the author's experience in Anylogic simulation, the two parts are fused to form the core part of the IPOS.

4. Combined with big data and artificial intelligence, the design adopts video recognition technology and case-based reasoning algorithm to further realize the intellectualization of the station.

5. From the perspective of system structure and function, the design and principle of the IPOS are put forward, and it is expected that the four functions can be realized at a high level: real-time acquisition of information in the station, visual presentation of the system interface, and reliable auxiliary decision-making suggestions.

6. The implementation of the system is mainly achieved by secondary development. It only needs to interface with the ISCS and Anylogic, so that the development cost and the difficulty can be greatly reduced.
ACKNOWLEDGMENT
This research was supported by the Basic Research on the application of science and technology program in Sichuan Province (2020YJ0255).

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