Research on Key Technologies for Intelligent Analysis of Escalator Risk Management in Large Transportation Hub

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Abstract. Transportation hubs are an important component of urban transportation systems, and their special equipment such as elevators and escalators have characteristics such as high working pressure, high frequency of use, and complex load changes. Once an accident occurs, it will have immeasurable impacts on public life safety and social stability. Building a smart large-scale transportation hub special equipment management system is the cornerstone of "smart city" construction, reducing equipment failure and accident rates, improving operational efficiency and service quality, as well as reducing operating costs and improving the economic benefits of enterprises. This article discusses the risk management of special equipment in transportation hubs from several aspects, including quality control of equipment maintenance and upkeep, investigation and risk assessment of equipment hazards, training on equipment operation safety, improvement and inspection of safety management systems, and emergency response to accidents. A risk governance intelligent analysis model with five levels of description model, judgment model, prediction model, decision model, and value model has been proposed as an indicator to evaluate whether the process of intelligent analysis of special equipment risk governance is "intelligent".

1.Introduction

Building a smart large-scale transportation hub special equipment management system is the cornerstone of "smart city" construction. Risk management of special equipment such as escalators and elevators in transportation hubs is an important measure to ensure safety production and public safety. From the perspective of public safety, transportation hubs are an important component of urban transportation systems, such as escalators, elevators, etc., closely related to the safety of passengers' lives and property. Once an accident occurs, it will have an immeasurable impact on public life safety and social stability; From the perspective of the characteristics of the equipment itself, escalators have characteristics such as high working pressure, high frequency of use, and complex load changes, all of which increase the risk of equipment failure and accidents; Risk management of transportation hub escalators can reduce equipment failure and accident rates, improve operational efficiency and service quality, while also reducing operating costs and improving the economic benefits of enterprises. By introducing advanced descriptive, diagnostic, predictive, and decision-making techniques, intelligent analysis of risk management can be achieved, enabling more accurate identification of escalator risks and improving governance efficiency.

The safety management of transportation hubs has always been a focus of research both domestically and internationally. Ping Zhong analyzed the construction and operation of comprehensive transportation hubs and constructed a risk control decision model[1]. Hongxi Di elaborated on the principles of risk construction, model construction, and risk response measures for intelligent transportation platforms[2].Zheng Han proposed a calibration method for determining model parameters of transportation hubs for dynamic traffic flow planning[3].Xiaolun Wang and Xupeng Zhang conducted a failure analysis on the brake system of elevators using the AHP method, identified the main risk points of the braking system, and proposed governance measures[4].Zhang and Xupeng proposed a certification method for the safety of escalator functions in use[5].Zhang and Xupeng used a similar method to determine the risk points for using escalators[6].Xupeng Zhang Propose a large-scale escalator risk analysis method[7].Xupeng Zhang proposed a functional safety certification method for public transportation escalators based on the theory of functional safety and the practical application of electrical safety in public transportation escalators[8].Xupeng Zhang proposed a functional safety certification method for public transportation escalators based on the theory of functional safety and the practical application of electrical safety in a large number of public transportation escalators[9].In terms of intelligent research, Zhang Xupeng believes that elevator intelligence is not only a smart monitoring terminal, but also an intelligent solution, intelligent perception means, intelligent processing means, and intelligent scene applications. He describes the main content and key

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support technologies of elevator intelligent application scenarios [10].However, the level of intelligence in safety management for large transportation hubs is not high, and there are not yet mature application scenarios[11]. There is still a gap in research on the intelligence of risk management for escalators in transportation hubs, including research frameworks and analytical models.

2. Object and content of intelligent analysis for risk management of escalators in transportation hubs

The risk management of transportation hub escalators, in addition to establishing an intelligent platform to achieve functions such as data collection, analysis, storage, and display, as well as real-time monitoring, fault diagnosis, risk assessment and early warning, to achieve comprehensive management and supervision of transportation hub escalators. In addition, it also includes research on quality control technology for equipment maintenance and upkeep, hazard investigation and risk assessment of equipment itself, and safety training for equipment operation, Improvement and inspection of safety management system, emergency response to accidents. Relevant departments and institutions shall conduct compliance supervision and inspection of special equipment in transportation hubs to ensure the safe production and legal use of the equipment.

Relevant departments and institutions shall conduct compliance supervision and inspection of special equipment in transportation hubs to ensure the safe production and legal use of the equipment. For example, third-party inspection agencies control the quality of the design and manufacturing process of escalators[12].

For equipment that exceeds or approaches the design life of the equipment, it is necessary for the inspection agency to conduct necessary evaluation processes on the basis of safety assessment, including the safety, reliability, and usage environment of the equipment itself. A risk assessment model should be established to analyze the potential risks of the equipment and develop corresponding safeguard measures.

3.Intelligent analysis model for risk management of escalators in transportation hubs

The author believes that there are four levels of intelligent analysis models for escalators in transportation hubs. Based on this, this article proposes a five level intelligent analysis model for risk governance - the first is a descriptive model that describes what happens; The second is a critical model, which determines why it occurs and whether it can be avoided in the future; The third is a predictive model that analyses the possible consequences and the necessary conditions for their occurrence; The fourth is the decision model, which analyses how to make wiser and more effective decisions for managers and operators; The fifth is the value model, which allocates resources reasonably, obtains the optimal price solution, and evaluates whether the process of intelligent analysis for risk management of special equipment is "intelligent"[13].

3.1.Descriptive model

At the level of descriptive models, the main approach is to monitor the operating status of devices in real time, obtain data such as their working status and operating parameters, and comprehensively and accurately describe the device status. At the level of descriptive models, the main approach is to monitor the operating status of devices in real time, obtain data such as their working status and operating parameters, and comprehensively and accurately describe the device status. The specific content of a descriptive model includes real-time monitoring of key parameters such as temperature, pressure, and vibration, monitoring of the operating sound and appearance of the escalator, as well as recording and analyzing the operating history of the equipment, in order to promptly detect abnormalities and faults in the equipment. In this process, the real-time, accuracy, and reliability of monitoring data are crucial. Descriptive models can be classified into various types, such as discriminant analysis, cluster analysis, factor analysis, etc. The current common form of human-machine interface is the leadership desktop or dashboard, which can combine GIS technology and digital twins to form a risk map of escalators in transportation hubs.

3.2.Judgment Model

At the level of critical models, it is mainly based on the device status information obtained from descriptive models to determine the cause and nature of device problems, as well as potential problems that may occur in the future. At the level of critical modeling, the main tasks are problem diagnosis and risk assessment, providing a basis for subsequent risk control and decision-making. The specific content of a discriminative model includes anomaly detection and fault diagnosis algorithms based on monitoring data, evaluation of equipment performance, and prediction and classification of possible equipment faults. In addition, expert knowledge and experience can be utilized to manually judge and analyze the operational status of equipment.

Judgment models typically involve the underlying structure and relationships of data, attempting to assist analysis through the features of the data. A judgment model is a type of model based on data and algorithms, which can be divided into various types, such as probability based models, rule-based models, machine learning based models, etc. It uses the features of data to construct models to assist decision-makers in making wiser and more effective decisions. When constructing a judgment model, it is usually necessary to consider the characteristics and distribution of the data, as well as the complexity and predictive ability of the model. In addition, it is necessary to evaluate and validate the

model to ensure its ability and effectiveness in assisting decision-making.

Taking rule-based models as an example, it is a rule-based model that extracts some rules and experiences through the analysis and summary of historical data, and applies them to new data. For example, for equipment inspection and testing, by analyzing and summarizing historical cases, some rules and experiences can be extracted and applied to daily work. For the quality of inspection reports, the definition rules for qualified and unqualified reports can be checked. For example, if one important project fails and there are more than five general projects that fail, according to the rules, they can be defined as overall equipment failure.

3.3.Prediction Model

Predictive models mainly predict the possible future development trends of equipment based on its current status and historical data, and take corresponding measures in advance for prevention. Based on the current status and historical data of the equipment, predict the possible future development trends and faults of the equipment, and take corresponding measures in advance to prevent them. The specific content of predictive models may include: equipment lifespan prediction based on machine learning algorithms, fault prediction, etc. Through deep mining and analysis of equipment operation data, predict the health status and development trend of equipment, as well as possible types and times of future faults.

Predictive models are statistical models that can be classified into various types, such as regression models, time series models, classification models, machine learning algorithm based models, etc. The common feature of these models is that they all use historical features of data to construct models and use these features to construct models for predicting device status. Predictive models cannot guarantee the accuracy of predictions, and it is necessary to evaluate and validate the model to ensure its predictive ability and accuracy.

For escalators in transportation hub scenarios, as the brand and specifications are basically the same, and the usage environment is also roughly the same, based on the conclusions of the judgment model and combined with historical data characteristics, systematic risk conclusions can be drawn. At the end of 2022, Beijing issued a warning notice regarding the increasing trend of systemic risks in emergency rescue equipment and lighting.

3.4.Decision Model

A decision model is a data and algorithm based model used to assist decision-makers in making wiser and more effective decisions. Translate the above described models, judgment models, and prediction models into specific decision recommendations or action plans to help managers better understand and respond to complex situations. Although decision models can help researchers better understand and respond to complex decision-making problems, and assist decision-makers in making wiser and more effective decisions, they cannot guarantee the accuracy of decisions. Decision makers need to comprehensively consider and judge based on actual situations and experience to make wiser and more effective decisions.

3.5.Value Model

At the value model level, the main focus is on cost-benefit analysis of equipment maintenance and replacement, rational allocation of resources, and achieving cost optimization and maximum benefits. Value models can be divided into various types, such as utility based models, cost based models, risk based models, etc. The common feature of these models is that they all use data features to construct models, analyze the goals and constraints of decision-making problems, and use mathematical methods to evaluate and optimize decisions, in order to assist decision-makers in more wise and effective evaluation of the value of the previous models.

In intelligent models, the value model is a model used to evaluate and optimize decisions. Value models typically involve the underlying structure and relationships of data, and attempt to assist decision-makers in making wiser and more effective decisions by analyzing the characteristics of the data. The specific content of the value model may include: equipment maintenance and replacement decision algorithms based on cost-benefit analysis, comprehensively considering factors such as equipment maintenance costs, replacement costs, and usage benefits, and formulating the optimal decision plan. In addition, personalized device management strategies can be developed based on different usage scenarios and requirements of the devices to maximize their value.

Based on the above five levels, comprehensive, accurate, and efficient monitoring, diagnosis, prediction, and decision support can be carried out for special equipment in transportation hubs, thereby effectively improving the safety and stability of the equipment, reducing risks and costs. Meanwhile, with the continuous development and progress of technology, we can continuously optimize and improve the content and methods of these levels, achieving more refined and intelligent management of special equipment in transportation hubs

4.Suggestions for promoting the safety management of special equipment in large transportation hubs

In promoting the safety management of special equipment in large transportation hubs, future safety management will pay more attention to diversified cooperation and co governance. The government, enterprises, society and other parties will work more closely together to promote the improvement and innovative development of safety management level.

5.Conclusion

1.The research background of risk management for escalators in transportation hubs is multifaceted, including the needs of safety production and public safety, as well as equipment characteristics, industry regulatory and policy requirements, and the needs of urban transportation hub operation management.

2.The intelligent analysis model for risk management of escalators in transportation hubs is the foundation of intelligent supervision of escalators.

3.The intelligent analysis model for escalator risk management is hierarchical and descriptive, describing what happens; A critical model to determine why it occurs and whether it can be avoided in the future; Predictive models, analyzing possible consequences and the necessary conditions for their occurrence; Decision model, analyzing how to make wiser and more effective decisions for managers and operators; Value model, obtain the optimal price solution, and evaluate whether the risk governance process is "intelligent".

4.Risk management of escalators in transportation hubs involves comprehensive, accurate, and efficient monitoring, diagnosis, prediction, and decision support of escalators in transportation hubs. It can also be applied to other similar intelligent management scenarios.

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