# Risk Management of Subway Shield and Text Mining

Subjects: Engineering, Civil

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Among the construction methods for subway projects, shield method construction technology has become a more widely used construction method for urban subway construction due to the advantages of a high degree of construction mechanization, low impact of the construction process on the environment, and strong adaptability of the shield machine to the stratum, etc. However, because of the complexity of the surrounding buildings (structures) in the subway construction, coupled with the diversity of the subway shield method construction activities and the uncertainties in the construction environment, to a certain extent, it is determined that the subway construction process is very complicated.

metro construction shield method text mining risk management

## 1. Introduction

Since the 21st century, the construction of rail transportation has been increasing, and urban rail transportation represented by the subway has the characteristics of large passenger capacity, high safety, high speed, low pollution, low energy consumption, etc., which largely relieves the traffic pressure in the city. However, the subway construction process is complex; the shield method is the main technology of subway construction, but safety accidents occur frequently. Subway shield construction safety risk management has defects and deficiencies. Risk management relies on subjective experience, the lack of mining, and the utilization of objective text data; it is difficult to meet the needs of subway shield construction safety risk management. Therefore, this research carries out subway shield construction safety risk identification based on safety risk text data, extracts coping strategies and measures for key risks, and plays an important role in helping to improve subway shield construction site safety management.

## 2. Research on Risk Management of Subway Shield

Li et al. took shield collapse accidents as the research object, analyzed the formation mechanism of construction workers' safety ability, and built a construction workers' safety ability model based on the perception and judgment of hidden dangers [1]. Chen et al. combined the triangular fuzzy number and cloud theory in the Bayesian network to build a risk analysis model for the underpass section of the shield and conducted risk assessment by taking the actual project as an example [2]. Yin et al. established the safety risk network structure of subway shield construction based on social network analysis and identified key risks with line centrality as the standard to provide

a decision-making basis for risk control [3]. Taking Nanning Metro Line 3 as the background, Liu et al. divided the shield construction section to establish the shield construction structure model and identify key risk factors via matrix weight calculation [4]. Based on Bayesian networks, Chung et al. established a TBM risk analysis model for shield construction, systematically identified potential risk events of shield construction, estimated the countermeasures cost of accidents, and assessed the risk level of potential risk events [5]. According to the geological risks of subway shield construction, Nezarat et al. used a fuzzy analytic hierarchy process to sort various risk factors so as to guide the shield construction on site [6]. Yazdani et al. proposed a risk assessment model based on fuzzy set theory to evaluate risk events during subway shield construction and compared it with traditional risk assessment methods [7]. Zhou et al. used complex networks to analyze subway construction accidents and finally obtained a directed powerless network with 26 vertices and 49 edges. Via data analysis, immune strategies were adopted to reduce network efficiency and guide the safety management of subway shield construction on site [8]. Xue et al. set up the evaluation index system of excavation face stability based on the underpass river of shield tunneling, calculated the weight by the AHP-entropy weight method, and established the evaluation model of excavation face stability based on the thought point method [9]. Ren et al. set up a construction safety risk evaluation index system for buildings adjacent to shield construction in a certain section of Metro Line 3 in Xi ‘an and used a fuzzy comprehensive evaluation method to evaluate the safety risk level of shield construction in the area [10]. Chen et al. combined subjective and objective methods to identify the safety risk factors of subway shield construction built an accident causative model with an interpretive structure model and analyzed the influence relationship between the factors with a decision laboratory [11]. Wang et al. took the Wuhan subway project as an example, conducted an overall analysis of the factors affecting the safety system of subway operation tunnels, and established a hierarchical structure model. On the basis of comprehensive risk evaluation, the risk grade of the tunnel shield construction section is determined by the fuzzy synthesis judgment model, maximum membership principle, and $R = P \times C$ [12]. Taking the Tianjin Metro project as an example, Pan et al. established a comprehensive index system of shield tunnel construction safety risk system based on fuzzy entropy theory. In addition, in order to quantitatively analyze the coupling degree between various factors in the safety risk system, a calculation model of coupling degree is established based on the coupling degree theory in physics [13]. Cao et al. studied a method of establishing risk analysis standards in shield tunnel construction: 3D numerical modeling using representative conditions. Risk control measures were then recommended based on the findings [14]. Huang et al. compared the TDCM evaluation method with the one-dimensional cloud model (ODCM) evaluation method and the Fuzzy Comprehensive evaluation method (FCEM) and discussed the advantages and applicability of the TDCM evaluation method [15].

## 3. Application of Text Mining in Subway Construction

Text mining is the process of obtaining interesting or useful patterns from unstructured text information. Text mining covers a variety of technologies, including information extraction, information retrieval, natural language processing, and data mining. Liu et al. applied text mining technology to tunnel engineering, established a tunnel engineering risk assessment index system with the help of R language and Jieba word segmentation, and developed a tunnel engineering risk assessment system on this basis [16]. Liu et al. collected the subway

construction safety accidents after the 21st century, established a construction safety accident database, identified 48 due factors and 13 accident types, used association rules and complex networks to build a subway construction safety accident causation network, and conducted immune research on nodes [17]. Xu et al. took the safety accident report as a corpus and identified the risk factors and risk correlation relationship of subway construction safety based on text mining method, including causality and coupling relationship, and established a risk assessment model based on interpretive structure model and Bayesian network [18]. Ji et al. used a web crawler to collect subway construction safety accident cases, identified 67 risk keywords by text mining method, established a subway construction safety risk network via a complex network, and identified key risk nodes. Then, the risk probability reasoning was carried out based on the Bayesian network, and the cost control was carried out via scenario analysis [19]. Son et al. conducted text mining of bidding documents and contract documents of large-scale EPC projects in South Korea and established a schedule delay estimation model to assess the forecast schedule risk so as to determine the appropriate project duration [20]. Li et al. used association rules to find the risk correlation of subway engineering, obtained 45 subway engineering construction monitoring combinations, and proposed risk countermeasures [21].

Zhang et al. studied the application of data mining technology in the information processing of the subway automatic data acquisition system and proposed the framework of the data mining system. Based on subway data acquisition technology, this research studies the analysis method of subway passenger flow and travel information. By using data mining technology and statistical analysis, the metro OD matrix and traffic rate are derived from the collected data, and the travel time distribution of passengers is described in detail, which is of great significance to the scheduling and management of the metro system [22]. Hsu et al. developed a responsive passenger letter system for the Taipei Metro case study example. After random sampling of passenger letters with text types was obtained, text mining technology in text letter files was used to find customary or even new keywords to improve service quality, such as customer satisfaction [23]. Mo et al. propose a measure that uses data mining techniques to create structured data sets for subway system equipment by analyzing historical maintenance records to monitor its daily status and possible fault development trends and attempt to apply predictive dimensions before any equipment actually fails [24]. Juan et al. extracted five years of subway accident records from the document. Via text clustering, the main influencing factors of subway delay are obtained. The relationship between the influencing factors and subway delay was established by using a logit regression model [25]. Chang et al. explored data-driven security risk assessment and response models via deep learning and complex network theory. Based on key security risk factors, corresponding risk countermeasures are proposed to verify the effectiveness and applicability of the data-driven security risk management model [26].

Mou et al. studied the subway operation hazard identification algorithm based on the text mining of subway operation logs, and the research results showed that the AFP-tree algorithm could significantly improve the computing efficiency and a total of 25 types of effective critical hazard sources were excavated via the analysis, and the research results could provide an important basis for the subway operation unit to achieve “prior” accident prevention [27]. Ye Cheng et al. proposed a classification method based on an improved BERT model and a structured retrieval method based on a knowledge graph to realize text classification and efficient data retrieval of subway construction hidden dangers and provide support for the development and application of the integrated

system. At the same time, this research can also provide references for text processing, data retrieval, and management in the field of architecture based on deep learning and knowledge graph technology [28]. Pan et al. proposed a text framework for automated analysis of hidden danger detection based on text mining and visualization technology, which was applied and verified in the analysis of construction safety hidden danger detection records of Wuhan Metro from 2016 to 2018. The experimental results show that the framework can effectively excavate the key points and visual information corresponding to 34 types of hidden dangers [29]. In view of the massive unstructured subway construction hidden danger text, Hei et al. proposed the idea of using text mining technology and visualization technology to analyze subway construction hidden danger so as to transform abstract text data into visual information, assist future hidden danger investigation and provide data support for it, which can be used for subway enterprises to compile hidden danger investigation yearbook and use the visual analysis results. It has practical application value in worker safety training [30].

Li et al. used R language and text mining methods to carry out word segmentation processing, feature item selection, vector space model construction, and co-occurrence rule recognition for accident reports and visualized text mining results by using word cloud and network structure graphs. Six key risk factors and 23 general risk factors of subway construction safety accidents were found [31].

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