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Intelligent Analysis Model for Civil Aviation Employees Safety Supervision Based on Knowledge Graph

Hao Tu[1, 2], Ping Zhang[1, 2], Tie Cao[1, 2], Jinhong Wei[1, 2]

[1]The Second Research Institute of CAAC, Chengdu, China
[2]Civil Aviation Electronic Technology Co., Ltd, Chengdu, China

Abstract: Ensuring the safety of civil aviation employees is crucial for the overall safety and quality of the aviation industry. However, traditional methods of safety supervision are inefficient. This research proposes a regulatory approach based on knowledge graph technology, aiming to extract relationships from safety incidents involving civil aviation employees, establish a framework for safety risk analysis, and utilize the Neo4j graph database to provide comprehensive visualized data support for the safety supervision of civil aviation employees. This approach has the potential to enhance the safety supervision of civil aviation employees and contribute to overall aviation safety.

Keywords: Civil aviation safety; Knowledge Graph; Civil Aviation Employees Safety Supervision.

1. Introduction

Civil aviation safety is the foundation of the civil aviation industry, which places extremely high demands on the safety and quality of civil aviation employees. However, traditional methods of supervising the safety of civil aviation employees suffer from various issues such as low level of informatization, data silos, and fragmented data[1]. These problems result in inefficiencies in the supervision of civil aviation employees' safety. Additionally, with the increasing number of civil aviation employees and the expanding nature of their tasks, traditional methods of safety supervision are no longer able to meet the regulatory authorities' demands for supervising the safety of civil aviation employees[2].

With the development of technologies such as big data, cloud computing, and artificial intelligence, information technology has gradually entered the field of civil aviation[3]. By extracting target data from a large amount of raw data and implementing intelligent analysis of the data, the application level and management efficiency can be directly or indirectly improved. However, research on information technology for the safety supervision of civil aviation employees is scarce, with the focus primarily on management systems and mechanisms[4].

The technology of civil aviation employee safety supervision based on the knowledge graph aims to propose a method that utilizes the knowledge graph to extract relationships from civil aviation employee safety incidents, establish a framework for safety risk analysis, and utilize the classification query, statistical analysis, and associated path analysis capabilities of the Neo4j graph database to conduct multidimensional and multilevel analysis and exploration of risk incidents. This technology aims to provide comprehensive visualized data support for the safety supervision of civil aviation employees.

2. Technical Principles

2.1. Knowledge Graph Technology

Knowledge graph is a structured graphical model used for representing and organizing knowledge[5]. It consists of nodes and relationships between nodes, aiming to capture the associations between entities and concepts. Its origins can be traced back to research in the field of artificial intelligence and the semantic web. In the 1980s and 1990s[6], it was recognized that for computers to understand and utilize human knowledge, knowledge needed to be represented in a structured manner. This led to the development of the concept of knowledge graph.

Google introduced a knowledge search application based on knowledge graph, which quickly gained popularity in academia and the business community due to its simplicity and comprehensibility [7]. It has evolved into a comprehensive, complete, and structured knowledge system. It not only encompasses a vast amount of data but also provides a convenient and efficient way for information retrieval, analysis, and decision-making, meeting the needs of various domains.

As an important artificial intelligence technology, knowledge graph can help us analyze data more effectively and provide efficient decision support [8]. It has become an integral part of many fields, including search engines, question-answering systems, conversational AI, and personalized recommendations.

2.2. Technology for Civil Aviation Employee Safety Supervision Based on Knowledge Graph

The technology for civil aviation employee safety supervision based on knowledge graph utilizes the fundamental methods of knowledge graph to represent data in a graphical structure. It organizes entities such as airports, regulatory authorities, safety incidents, incident outcomes, and measures into a network of entity relationships and attributes, establishing a knowledge graph for civil aviation employee safety supervision. By constructing the knowledge graph, integration and correlation among different data sources can be achieved, resulting in comprehensive and accurate knowledge representation.

This graph can integrate various types of data, including background information, qualification certifications, training records, and safety incidents of the employees. It helps regulatory authorities obtain a comprehensive understanding of the safety situation of civil aviation employees and

provides assistance in decision-making when safety incidents occur.

3. Construction of Knowledge Graph for Civil Aviation Employee Safety Supervision

Data is a core issue in constructing the knowledge graph for civil aviation employee safety supervision. The data for this research is sourced from safety incidents that occurred in airports under the jurisdiction of two regulatory authorities over the past three years. The regulatory authorities collected the safety incident data from their respective airports in a standardized format. The collected data is organized according to the contents shown in Table 1.

Table 1. Basic data of the civil aviation employees' safety analysis model

Data Categories	Data Types
Entity	Accident Airport Authorities
Relationship	Accident_result Accident_solution Accident_type Accident_year Casualties Economic_losses

The collected data is first subjected to data cleaning, where invalid data with missing key elements or duplicates are removed. Data that does not conform to the standards is standardized into a unified format. Finally, the cleaned data from all airports is consolidated. Subsequently, nodes can be established and entity relationships can be extracted using Neo4j.

The formatted data is used to build a knowledge graph using Neo4j. The knowledge elements in the graph include entities, relationships, and attributes. Entities are established as nodes in Neo4j. Entities are the basic elements in the composition of a knowledge graph and are typically referred to by their names. Entities can also be abstracted to form concepts and are classified accordingly. For example, entities such as A airport, B airport, and C airport can be abstracted into a concept like "Airport." Attributes provide detailed descriptions of entities. For instance, under the concept of "Accident," attributes such as time and occurrence zone are associated with each accident. Relationships reflect the connections between entities. Examples of relationships include "belongs" (e.g., an airport belongs to the Central-South Regional Administration) and "occurred" (e.g., an accident occurred at an airport due to passenger trespassing). In this study, the relationships between two entities are described in the form of "Entity 1-Entity 2" .

4. Intelligent Analysis of Knowledge Graph for Civil Aviation Employee Safety Supervision

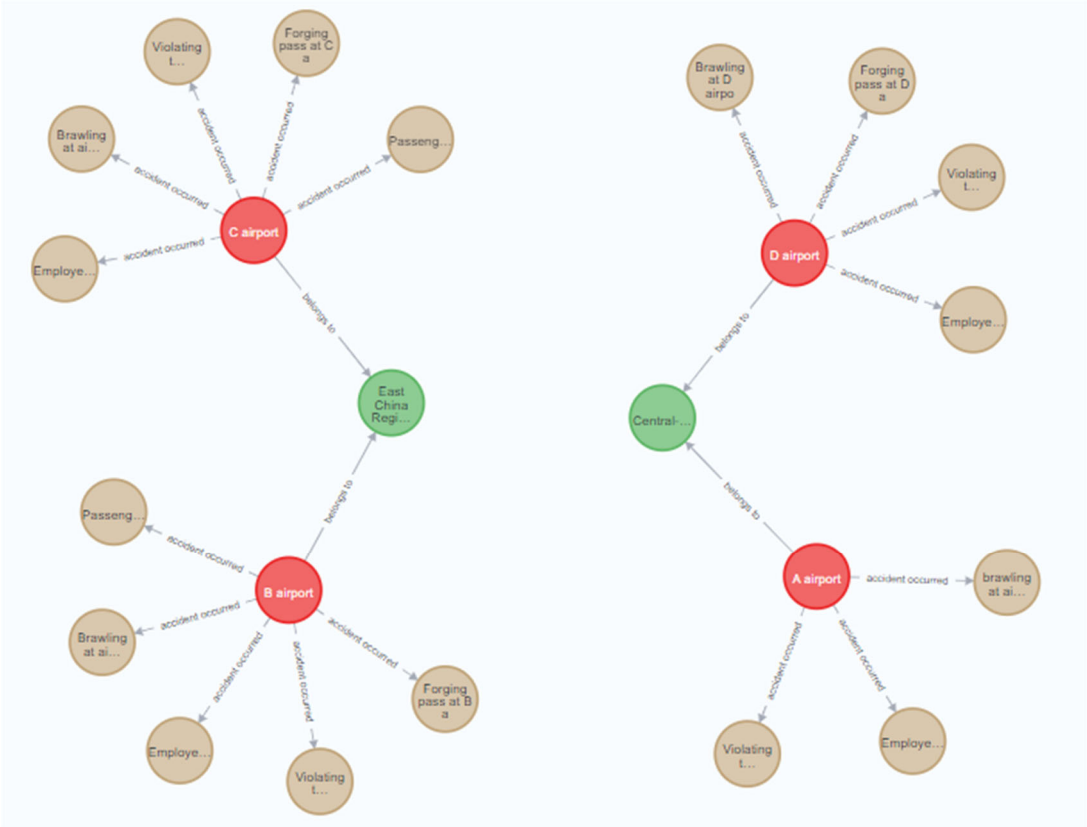

Figure 1. Modeling process of civil aviation employees' safety analysis model

The knowledge graph for civil aviation employee safety supervision, built using Neo4j, is shown in Fig. 1. Nodes of different colors represent different entities（Green nodes represent authorities, red nodes represent airports, and gray nodes represent accidents.）, while the connections between nodes represent the relationships between entities. Combined with the querying, statistical analysis, and path analysis capabilities of the knowledge graph, comprehensive analysis

of civil aviation employee safety incidents can be conducted. This can assist regulatory authorities in identifying potential issues in current management and implementing targeted improvements.

4.1. Applications of Accident Statistics

The analysis of accident statistics primarily involves analyzing the quantity of entities, events, and losses. By utilizing data analysis charts such as bar charts, pie charts, and line graphs, the characteristics and patterns of risk occurrence can be summarized, providing targeted recommendations for risk prevention efforts. The queries related to accident statistics can be categorized into three types: counting the quantity of a single entity, counting the number of events, and calculating the losses from events.

4.2. Applications of Accident Classification Query

The application of Accident Classification Query involves querying the basic information and distribution of events from different dimensions. The query results are often presented in the form of tables or graphs. Graph-based results can provide a more intuitive representation of detailed entity information and the relationships between entities. This query can be used to retrieve the attributes and related information of a specific accident, as well as to inquire about the specific content included in each category of entities. It can also be used to analyze the distribution of accidents based on entities such as cities, years, event types, locations, and causes. This facilitates the understanding of the detailed content of safety incidents by management organizations.

4.3. Applications of Accident Path Analysis

In this knowledge graph, different entities can be connected through multiple intermediary entities, forming association paths. Based on these paths, relationships between accidents and the patterns of risk evolution can be discovered. Analyzing these paths can help explore management issues related to relevant risks. Specifically, by connecting factors such as the causes, outcomes, locations, and post-incident response measures of various accidents, a path can be formed by linking these two layers of relationships, providing an explanatory framework for management organizations.

5. Conclusion

By applying the knowledge graph to the vertical domain of civil aviation employee supervision and utilizing the vast amount of data within the domain, it can provide management organizations with a clear overview. It assists in analyzing potential issues and providing decision support, offering information technology support to regulatory personnel and playing a significant role in civil aviation safety. However, the current data involved in this technology limits the information that the knowledge graph can present. In the future, by combining artificial intelligence technology, it is possible to extract entity and relationship information from more data sources, expanding the coverage of the knowledge graph and providing more data and analytical application functions for civil aviation employee safety supervision.

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