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Emergency Decision-Making of Hazardous Chemical Safety Production Safety Accidents Based on Knowledge Graph

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Abstract: This paper discusses how to use knowledge graph technology to assist the process of emergency decision-making in the safety production accident of hazardous chemicals. By building a knowledge map covering multi-dimensional information such as the characteristics of hazardous chemicals, accident cases, and emergency resources, the paper aims to improve the efficiency and accuracy of emergency response, and provide scientific and reasonable decision support for accident handling. Therefore, the paper expounds in detail the current situation of hazardous chemical and production safety accidents, the construction method of knowledge graph and the application scenario in the actual emergency decision, in order to reference.

1. Introduction

With the acceleration of the industrialization process, the problem of safety production of hazardous chemicals has become increasingly prominent. Once a production safety accident occurs, the consequences are often very serious, not only will cause casualties and property losses, but also may cause a long-term impact on the environment and society. Therefore, how to efficiently and accurately deal with the safety production accidents of hazardous chemicals has become an urgent problem to be solved. As a powerful knowledge representation and reasoning tool, knowledge graph has shown great potential in the field of emergency decision-making. It can integrate the semantic and pragmatic information of chemical accident data, and realize the continuous accumulation of accident knowledge through data mining and information processing. By extracting the key information of accidents and making structured and standardized processing, after storing the knowledge graph, classification query, statistical analysis, correlation path analysis and other tasks can be carried out for accidents, so as to reveal the potential rules and trends of accidents. Based on the knowledge graph technology, this paper studies the emergency decision of hazardous chemical safety production accident deeply.

2. The current situation of safety production accidents in hazardous chemicals

Hazardous chemicals, namely hazardous chemicals, are involved in the production, storage, transportation and use of an extremely high risk. Once an accident occurs, it will often cause serious casualties, property losses and environmental pollution. In recent years, although China has made significant progress in the safety management of hazardous chemicals, the safety accidents of hazardous chemicals are still frequent and the situation is still grim.

2.1 Frequent accidents and serious consequences

In recent years, the frequent hazardous chemical production accidents in China not only brings a serious threat to the safety of people's lives and property, but also has a negative impact on social stability and economic development. According to statistics, the human casualties and property losses caused by hazardous chemical accidents are high every year, including some major and major accidents, which have brought great shock to the society.

2.2 Various accident types with complex causes

There are various types of hazardous chemical production safety accidents, including leakage, explosion, fire and so on. These accidents often involve multiple factors, such as equipment aging, operation error, mismanagement and so on[1]. In addition, some accidents are also affected by the natural environment, man-made damage and other factors, making the causes of the accidents more complex.

2.3 Supervision is difficult and the responsibility is not in place

The supervision of hazardous chemical production safety involves multiple departments and links, which requires the cooperation of all parties. However, in the actual work, due to the difficulty of supervision, the implementation of responsibility is not in place and other reasons, some enterprises have safety risks can not be timely rectification, some illegal behaviors can not be effectively contained.

3. Knowledge graph construction techniques

3.1 Basic concepts and characteristics of the knowledge graph

The Knowledge Graph (Knowledge Graph) is a structured graphical model for representing and organizing knowledge. It displays knowledge in the form of graphics by modeling entities, properties, and relationships. In the field of hazardous chemical production safety accidents, the knowledge graph can help us to systematically organize and manage all kinds of information related to accidents, such as the characteristics of hazardous chemicals, accident types, emergency resources, etc.

The characteristics of the knowledge graph mainly include:

Semantic rich: can express complex semantic relationships, such as the interaction between hazardous chemicals, the correspondence between accident types and emergency resources, etc.

Strong scalability: With the addition of new knowledge, the knowledge graph can be continuously expanded and improved.

Good visualization effect: by graphically displaying the knowledge, making the knowledge more intuitive and easy to understand.

3.2 Construction method of the knowledge map of hazardous chemical safety production accidents

Step 1: Build hazardous chemicals and accident data sets

According to the Catalogue of Hazardous Chemicals (2015 Edition) formulated by the State

Administration of Safety, collect and sort out the relevant hazardous chemicals and accident data.

Step 2: Data preprocessing

The collected data was cleaned and collated to remove duplicate, incorrect, or invalid data. Data were standardized as needed to ensure data consistency and comparability[2].

Step 3: Entity identification and relationship extraction

Using natural language processing, machine learning and other technologies, the entities (such as the names of hazardous chemicals, accident types, emergency resources, etc.) and relationships (such as the interaction between hazardous chemicals, the corresponding relationship between accident types and emergency resources) are extracted from the text data.

Step 4: Knowledge graph construction

The extracted entities and relationships are imported into the knowledge graph building tool to form a preliminary knowledge graph.

The knowledge graph is optimized and adjusted as needed, such as removing redundant information, merging repeated entities, etc.

Step 5: Storage and query of the knowledge graph

The built knowledge graph is stored in the database for subsequent queries and use. We aim to furnish a user-centric and intuitive query interface, enabling users to promptly acquire knowledge and information pertaining to hazardous safety production accidents.

4. Application of knowledge graph in the emergency decision-making of hazardous chemical and production safety accidents

4.1 Accident analysis and prediction based on the knowledge graph

In the emergency decision-making of hazardous chemical production safety accidents, the construction of knowledge graph is the basic work. First of all, it is necessary to collect a large number of hazardous chemical production safety accident cases, regulations and standards, emergency disposal measures and other relevant information, and conduct pretreatment and structured treatment. Then, the knowledge graph technology is used to extract the entities, relationships, attributes in these information and build a knowledge graph. During the construction process, attention is needed to ensure the accuracy and integrity of the data, as well as the hierarchy and logical relationship of the graph.

Based on the constructed knowledge map, the in-depth analysis and prediction of hazardous chemical safety production accidents can be made. By mining the correlation relationship in the knowledge graph, the potential laws and trends of accidents can be found, which can provide strong support for accident prevention. At the same time, the historical accident cases and emergency response measures in the knowledge graph can also be used to analogy analyze similar accidents, so as to provide reference for the emergency treatment of current accidents. In addition, big data and machine learning technology can also be combined to predict and evaluate the probability and consequences of accidents, providing a scientific basis for emergency decision-making.

4.2 Dispatching and optimization of emergency resources

4.2.1 Integration and visualization of resource information

In the emergency decision-making of hazardous chemical production safety accidents, the scheduling and optimization of emergency resources is the key link. By constructing the knowledge map, the information of various emergency resources can be integrated and visualized. For example, the quantity, performance, distribution and other information of various emergency equipment can be displayed in the form of a map, so as to facilitate the decision makers to quickly understand the overall situation and distribution of resources[3]. At the same time, the number, skills, location and other information of emergency personnel can also be included in the map, to achieve a comprehensive control of emergency resources.

4.2.2 Resource Scheduling and optimization algorithm

In terms of emergency resource scheduling and optimization, the correlation relationship and path analysis function in the knowledge graph can be used to design corresponding algorithms. For example, according to the accident type and scale, it can be quickly located to the required emergency equipment and personnel, and the optimal scheduling path and scheme can be calculated. At the same time, the scheduling scheme can be adjusted dynamically according to the real-time state and change of resources to ensure the full utilization of resources and high effect response.

4.3 Decision support and decision assistance system

4.3.1 Intelligent Q & A and recommendation system

The decision support and decision assistance system based on knowledge graph can realize intelligent question and answer and recommendation functions. When the user enters the query question, the system can automatically retrieve the relevant information from the knowledge graph and give an accurate answer. At the same time, the system can also recommend the relevant knowledge and resources according to the users' query history and preferences, so as to help the users to better understand and deal with the safety production accidents of hazardous chemicals.

4.3.2 Generation and optimization of decision scheme

In the emergency decision, the generation and optimization of decision plan is the key link. The decision support and auxiliary decision system based on the knowledge graph can automatically generate a variety of feasible decision-making schemes according to the accident type, scale, environment and other factors. At the same time, the system can also use the correlation relationship and path analysis function in the knowledge graph to evaluate and optimize these schemes to ensure the scientific nature of the scheme[4].

4.3.3 Visualization and simulation of the decision process

In order to better support the decision making process, the decision support and auxiliary decision making system based on knowledge graph can also realize the visualization and simulation function of the decision making process. By showing the decision process in the form of a map, it can help the decision makers to understand the decision process and results more intuitively[5]. At the same time, the simulation technology can also be used to verify and evaluate the decision-making scheme to ensure the feasibility of the scheme.

5. Review, effect evaluation and comparative analysis of typical hazardous chemical production safety accidents

5.1 Review of typical hazardous chemical safety production accident cases

5.1.1 The "August 12" Ruihai Company dangerous goods warehouse explosion accident of Tianjin Port

On August 12,2015, a particularly serious fire and explosion occurred in the dangerous goods warehouse of Tianjin Port Ruihai International Logistics Co., LTD., resulting in 165 people killed, 8 missing and 798 injured, with direct economic losses of 6.866 billion yuan. The cause of the accident was the chaotic safety management of the dangerous goods warehouse of Ruihai Company, the illegal storage of a large number of inflammable and explosive dangerous chemicals, and the combination of weather conditions and other factors, which led to the occurrence of fire and explosion accident.

5.1.2 The "3·21" Special major explosion accident of Jiangsu Xiangshui Tianjiayi Chemical Co., Ltd

On March 21, 2019, a particularly serious explosion occurred in Jiangsu Xiangshui TianJiayi Chemical Co., Ltd., resulting in 78 deaths, 76 serious injuries and 640 people hospitalized, with a direct economic loss of 1.986 billion yuan. The cause of the accident was that Tianjiayi company had been illegal storage of nitrification waste for a long time, the serious lack of safety management, and the illegal operation of employees, leading to the explosion of nitrification waste and a chain reaction.

5.1.3 A chemical plant explosion in Texas

In April 2012, an explosion at a chemical plant in Texas killed dozens of people and injured hundreds of others. The cause of the accident was that the chemical plant failed to strictly comply with the safety operation procedures during the production process, which led to the chemical reaction out of control and eventually caused the explosion. The accident has brought great pain to the local community, and it has also caused an irreversible impact on the surrounding environment.

5.2 Effect evaluation and comparative analysis

In the above three cases, the timeliness and effectiveness of the emergency response was critical to reducing casualties and property losses. In the "August 12" accident in Tianjin Port, due to the sudden and rapid fire, and the complex and chaotic scene, there were some difficulties in the initial emergency response. However, under the strong leadership of the CPC Central Committee and The State Council, governments at all levels, the armed forces, the armed police, the public security and other rescue forces quickly assembled and carried out rescue operations, and finally successfully controlled the fire and stabilized the situation. In the "March 21" accident in Xiangshui, Jiangsu province, the local government and enterprises also quickly launched the emergency response mechanism, but due to the large scale of the accident and the wide range of impact, the rescue is relatively difficult. In the explosion accident of the chemical plant in Texas, due to the serious problems in the internal safety management system of the chemical plant, the emergency response was not timely and effective after the accident, resulting in large casualties and property losses.

From the causes of the above three accidents, they all have some common problems. First of all, these accidents involve the storage and use of hazardous chemicals, and there are problems such as chaotic safety management and illegal operation. Secondly, these accidents occurred in specific environments and conditions, such as the weather conditions in the "August 12" accident in Tianjin

Port and the nitrification waste storage in the "March 21" accident in Xiangshui, Jiangsu Province. In addition, these accidents have also exposed the relevant enterprises and departments in the safety production management of the deficiencies and loopholes. However, from the specific reasons, these accidents have their own characteristics. For example, the "8 ·12" accident in Tianjin Port was mainly caused by illegal storage of a large number of inflammable and explosive hazardous chemicals; the "March 21" accident in Jiangsu Xiangshui was caused by long-term illegal storage of nitrification waste and illegal operation; and the chemical plant explosion in Texas was mainly caused by serious problems in the internal safety management system of chemical plants.

5.3 Comparison of rectification measures and effects

In view of the problems and loopholes exposed by the above three accidents, the relevant enterprises and departments have taken a series of rectification measures. For example, after the "8 ·12" accident in Tianjin Port, Tianjin conducted a comprehensive investigation and rectification of and strengthened the storage and use of hazardous chemicals; after the "March 21" accident in Jiangsu Xiangshui, Jiangsu Province conducted a comprehensive investigation and rectification of chemical enterprises and strengthened the safety supervision and law enforcement of chemical enterprises; after the explosion of chemical plants in Texas, the US government and relevant departments also strengthened the safety supervision and law enforcement of chemical enterprises, and promoted the technical improvement and industrial upgrading of the chemical industry. These rectification measures have achieved positive results to some extent, and improved the level of safety production management of relevant enterprises and departments. However, due to the differences in laws, regulations, regulatory systems, cultural backgrounds and other factors in different countries and regions, there are also some differences in the implementation effectiveness and sustainability of the rectification measures.

5.4 Conclusion and recommendations

Through the in-depth review and comparative analysis of the typical hazardous chemical production accident cases, we can clearly see that both domestic and foreign, hazardous chemical production accidents are extremely destructive and unpredictable. These accidents not only pose a serious threat to the safety of people's lives and property, but also have a negative impact on social stability and economic development. The cause of the accident often involves illegal operation, lack of safety management, ineffective supervision and other aspects, these problems need to be paid great attention to.

To this end, first, enterprises and individuals should fully realize the importance of safe production of hazardous chemicals, enhance safety awareness and risk prevention awareness, and prevent the occurrence of accidents from the source.

Second, establish and improve the safety management system, improve safety facilities, to ensure that the storage, use, transportation and other links are to meet safety standards. At the same time, staff training should be strengthened to improve their safe operation skills and emergency response ability.

Third, the government departments should strengthen the supervision of hazardous chemical enterprises, severely crack down on violations of laws and regulations activities, and ensure that enterprises strictly abide by the safety production laws and regulations. At the same time, we should improve the regulatory system and improve the efficiency and level of supervision.

Furthermore, it is imperative to establish and refine the emergency mechanism for hazardous chemical production accidents in order to enhance the swiftness of emergency response and elevate the overall disposal capabilities. At the same time, emergency drills and training should be strengthened to ensure that accidents can be handled quickly and effectively.

6. Conclusion

In short, knowledge graph, as a new way of information organization, has a wide application prospects in the emergency decision-making of hazardous chemical safety production accidents. Through the construction of knowledge graph, the in-depth analysis and prediction of hazardous chemical safety production accidents, the scheduling and optimization of emergency resources, and the construction of decision support and decision auxiliary system can be realized. In the future, with the continuous development and improvement of technology, the application of knowledge map in the emergency decision-making of hazardous chemical production safety accidents will be more extensive and deep. At the same time, it is also necessary to strengthen the research and development and application and promotion of relevant technologies to improve the scientific emergency decision of hazardous chemical production safety accidents.

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