Analysis of Intelligent Question-answer Technology for Oilfield Safety Supervision based on Knowledge Graph

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Keywords: Knowledge Graph, Safety Supervision, Intelligent Q&A.

Abstract: Safety management is a typical knowledge-intensive task. In the process of oilfield safety supervision and management, it needs the support of a large amount of professional knowledge, which is scattered and stored in various data. Due to large amounts of data, various types and extensive sources, it is difficult to obtain valuable knowledge quickly and accurately by using manual methods. Therefore, with the help of relevant tools and methods in the field of artificial intelligence, it can provide intelligent knowledge support for oilfield safety supervision and management, thus helping to improve the safety management efficiency.

1 INTRODUCTION

Oilfield safety management is the key to ensuring oilfield safety production. With the advent of the era of "industry 4.0", adopting big data intelligent knowledge and realizing intelligent operation and maintenance of oilfield safety management is a key link to realize the construction of smart oilfields. The foundation of intelligent knowledge support is to have rich and structured available knowledge. In the absence of sufficient knowledge, it is a practical scheme to obtain knowledge from enormous data. According to the DIKW hierarchical model (Figure 1) (data, information, knowledge, wisdom), the transformation and promotion process of "data-information-knowledge-wisdom" is a process of continuous in-depth processing and refining of data and knowledge, and finally promoting the improvement of cognitive ability, problem-solving ability and innovation ability (Paulheim 2017, Kumar 2017). In this process, relevance and understanding are two very important factors. Only through correlation can we promote understanding. Only through in-depth understanding can we find new knowledge. This process also reflects the process of knowledge integration, accumulation and innovation. Therefore, based on the characteristics of the oilfield safety knowledge system, this paper analyzes the intelligent question-answer technical framework of oilfield safety supervision, to provide a reference for the follow-up construction of smart oilfields.

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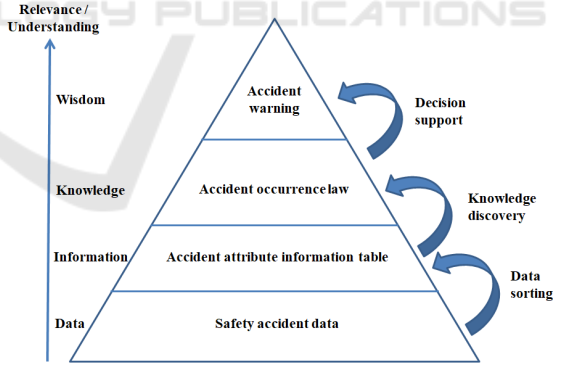

Figure 1: DIKW hierarchical model and data processing process (taking accident data as an example).

2 SAFETY KNOWLEDGE SYSTEM

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Wang, Y., Yang, C., Wang, W., Zha, J. and Huang, S.
Analysis of Intelligent Question-answer Technology for Oilfield Safety Supervision based on Knowledge Graph.
DOI: 10.5220/0011174400003444
In *Proceedings of the 2nd Conference on Artificial Intelligence and Healthcare (CAIH 2021)*, pages 64-68
ISBN: 978-989-758-594-4

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2.1 Features

(1) Driven by the demand for safety management knowledge. The object of intelligent knowledge support service is safety management. The core work of safety management includes the identification and analysis of safety risk factors, the formulation of safety risk response measures and accident emergency rescue plans, potential safety hazards investigation and safety pre-control, accident emergency rescue and safety accident handling, etc. The knowledge demand of these tasks is the driving factor of knowledge support. The key tasks such as knowledge structure modelling, automatic knowledge extraction and intelligent knowledge selection should be based on knowledge demand.

(2) Based on the general and expandable knowledge structure (Sawant 2019). Whether knowledge can meet the needs of supporting security management is closely related to the availability of knowledge, which depends on the organization and structure of knowledge. Therefore, the basic work of constructing a domain knowledge base is knowledge structure modelling. In order to integrate multi-source heterogeneous knowledge to the greatest extent, it is required to design a general and extensible knowledge structure, which directly determines the content and structure of the domain knowledge base.

(3) Taking multi-source heterogeneous data as raw materials. At present, there is no general domain knowledge base suitable for oilfield safety supervision and management, and the structured knowledge is relatively limited. Extracting knowledge from a large number of multi-source heterogeneous data has become a practical and effective way to obtain knowledge. These data include various management and technical materials from within the organization. A large part of these materials is stored in unstructured text, which not only provides rich data sources for knowledge extraction, but also increases the difficulty of knowledge acquisition.

(4) Utilizing automatic knowledge extraction. It is precise because the existing data has the characteristics of being multi-source, heterogeneous and large quantity, and the efficiency of using artificial methods is too low. Therefore, it is necessary to continuously extract valuable knowledge from various data sources using automatic knowledge extraction with the help of relevant technologies and methods in the field of artificial intelligence, so as to enrich and improve the knowledge base in the field of safety management and to realize the continuous accumulation of knowledge.

(5) Based on the knowledge base in the field of safety management. The best way to realize knowledge integration and reuse is to structure the knowledge. The knowledge extracted from different sources is stored through a unified structure mode to form a domain knowledge base. Through long-term accumulation and improvement, the knowledge base can provide rich knowledge sources for safety managements and basic conditions for safety management knowledge support.

(6) Taking knowledge intelligent selection as the approach. Different safety management problems or the same management problems have different requirements for the scope and granularity of knowledge in different situations. Knowledge intelligent selection is to automatically select the knowledge that users may be interested in from the knowledge base in the field of security management, or to provide accurate knowledge that can solve problems to support security management decisions.

(7) The result is to obtain the potential interest knowledge set or precise demand knowledge unit. When the requirements are not clear or the knowledge that meets the requirements is not unique, the results of the intelligent selection will be provided to the knowledge set which users are potentially interested in. When the demand is clear and the knowledge is unique, the result of the intelligent selection will be provided to the user's accurate knowledge unit. Through the interaction with users, we can further obtain accurate knowledge units from the potential interest knowledge set.

(8) The ultimate goal is safety management decision support. Assisting in safety management decision-making is not only the starting point of knowledge support, but also the ultimate goal of knowledge support. Through knowledge support, we can accurately and quickly obtain the knowledge required by the security management business, so as to improve the efficiency of security management decision-making and improve the scientificity and rationality of decision-making.

2.2 Frame Structure

In the process of intelligent knowledge support, three core problems need to be solved to achieve three support objectives (Nguyen 2020, Agibetov 2020): 1) knowledge structure modelling is used to solve the problem of knowledge structure, and the expandable knowledge structure mode is studied to support the effective integration of multi-source heterogeneous knowledge; 2) automatic knowledge extraction solves the problem of knowledge transformation efficiency, and constructs automatic knowledge extraction methods and models to support the continuous accumulation of domain knowledge; 3) knowledge intelligent selection solves the problem of efficiency and accuracy of knowledge acquisition, and supports safety management decision-making quickly and accurately by studying intelligent knowledge application scenarios and methods.

The above intelligent knowledge support process realizes the refining process from data to knowledge (Figure 2): obtain multi-source heterogeneous data sources (DS) - extract knowledge and store it in the security management domain knowledge base (KB) - identify the knowledge set of potential interest (IKS) - accurately obtain the required knowledge unit (RKU) according to the actual problems. Among them, DS comes from the data related to internal security management of the organization and the security-related data resources obtained from the Internet, which presents text, pictures, tables and other forms. It has the characteristics of being multi-source, heterogeneous and large quantity. Its value density is low and needs further screening and improvement to play its role. KB is the knowledge expressed and stored in a specific structure, which can be extracted from DS or edited manually, and can be reused. IKs is a collection of knowledge potentially interested by users selected from KB according to user security management business requirements. RKU is usually obtained by further analysis and processing based on the knowledge units in IKS and is directly used for security management decision support. This process generally requires human-computer interaction or automatic loading and execution by the business system. In addition, in the process of intelligent knowledge support, it needs the support of relevant technologies and tools in the field of artificial intelligence.

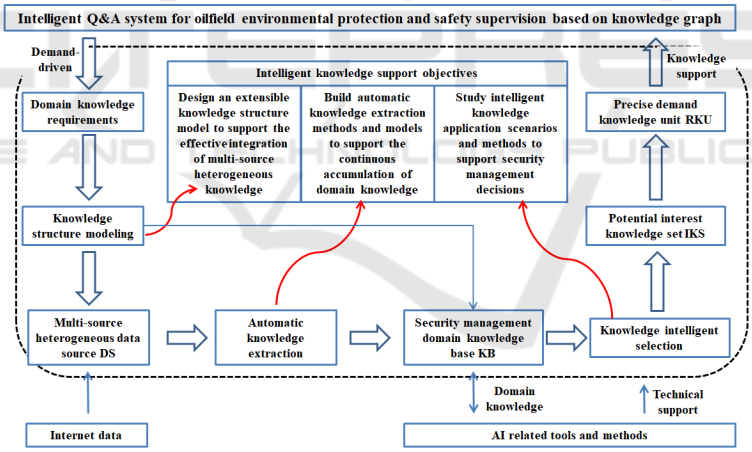

Figure 2: The framework of intelligent Q&A system for oilfield environmental protection and safety supervision based on knowledge graph.

2.3 Fragmentation of Knowledge Points

Intelligent knowledge support (Figure 3) aims to obtain the required knowledge comprehensively, quickly and accurately, to automatically analyse the knowledge demands by perceiving user characteristics and business situation characteristics, and to realize the intelligent acquisition of domain knowledge based on a knowledge base, rule base and model library, thus supporting security management decisions.

Access to knowledge demands mainly includes the following aspects:

(1) Based on the interactive system interface, actively input knowledge demand information. The search conditions entered by users in various knowledge search engines, the search questions put forward by users in the question-answer system, and the selection of knowledge modules in knowledge

navigation all reflect the knowledge needs and knowledge acquisition willingness actively expressed by users.

(2) Obtain user context information based on intelligent perception engines and automatically analyse knowledge needs. Use the interfaces provided by various system software to capture user information, operation behaviours, and objects of concern, and comprehensively analyse the user situation to obtain potential knowledge needs.

(3) Automatically analyse the knowledge requirements based on the data call requests of various management systems. Various management systems usually use the interface provided by the database to make data call requests. The data call requests of each business processing module in the system directly reflect the knowledge requirements of business processing.

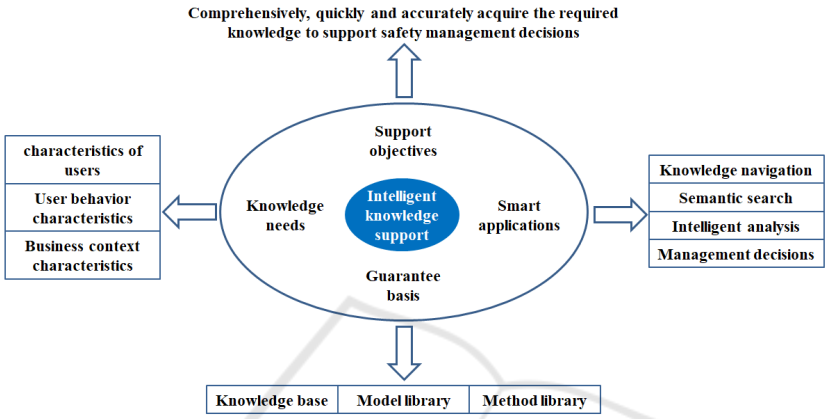

Figure 3: Overall implementation framework of intelligent knowledge support.

2.4 Constructing Knowledge Graph

(1) Knowledge base

The knowledge base provides knowledge content for intelligent knowledge support. The intelligent Q & A section of oilfield safety supervision based on knowledge graphs organizes and manages the knowledge related to safety management in the form of network structure, which is the core part of the domain knowledge base, while other non-network structured knowledge can be organized and managed through traditional relational databases and document management systems. For example, the user's basic information and system logs are still stored in the traditional databases, and the documents, pictures, videos, and other materials are still organized and managed based on the traditional file management modes.

(2) Model library

The model library provides intelligent knowledge support with models required for knowledge extraction and intelligent application. According to different functions, it can be divided into knowledge extraction model, analysis and statistics model, prediction and early warning model, etc. According to different implementation methods, it can be divided into sequence annotation model, classification prediction model, etc. According to different algorithms, it can be divided into a rule-based model, statistics-based model, deep learning model, and so on. In the process of knowledge extraction and recognition, multiple model libraries will be established.

(3) Method library

The method library provides various concrete implementation methods for intelligent knowledge support. These methods are usually embedded in modular programs, select appropriate models according to different needs, and process data or knowledge.

2.5 Collecting Supervision Problems

Knowledge of different granularity can be acquired as needed. According to the degree of user interaction, standardized knowledge acquisition approaches can be divided into three categories: knowledge navigation, intelligent search and knowledge recommendation. Knowledge navigation displays the knowledge structure and scope through the knowledge navigation menu or knowledge graphs, and gradually guides users to select the required knowledge content through user interaction. Knowledge search, by analysing the search conditions provided by users, accurately determines the actual knowledge needs of users, then matches the

knowledge in the knowledge graphs, and finally provides users with a relevant knowledge list or accurate knowledge content. Knowledge recommendation infers the list of knowledge that the user may be interested in according to the user's professional characteristics and historical search behaviours, and the user can further select the required knowledge content. Users still focus on learning normative knowledge, and improve their safety awareness and ability by mastering normative knowledge related to safety management.

3 CONCLUSIONS AGIBETOV A. & SAMWALD M.

Based on the knowledge modelling in the field of oilfield safety supervision, the intelligent knowledge support of oilfield safety supervision realizes the automatic extraction and transformation of knowledge elements into structured knowledge by using the relevant technologies and methods of artificial intelligence, achieves the intellectualization of knowledge acquisition by accurately understanding the knowledge requirements, and provides decision-making support for scientific and efficient safety management. Knowledge modelling is the design process of knowledge structure mode in the field of oilfield safety supervision and management. A reasonable knowledge structure mode is not only conducive to the integration and expansion of knowledge, but also supports the automatic reasoning and completion of knowledge, which is the basis for realizing intelligent knowledge support. Its design process should follow the principle of "starting from demands and ending with an application". Knowledge element extraction is a process of extracting key knowledge elements from various data sources and organizing and representing knowledge according to a specific structure. In the face of a large number of multi-source heterogeneous security data, it is particularly important to realize the automatic extraction of knowledge elements with the help of intelligent means. It is a process of testing the knowledge structure model. The dynamic and continuous accumulation of domain knowledge base provides a rich source of knowledge for intelligent knowledge selection. Knowledge intelligent selection and decision-making support should first obtain and understand the actual needs of users for knowledge. On this basis, appropriate tools and methods are used to realize the intelligent selection and processing of knowledge, and finally to give feedback to users as accurate knowledge as possible to assist in supporting safety management decision-making. Oilfield safety supervision is driven by the demands for safety management knowledge, based on the structured knowledge base in the field of safety management, through automatic knowledge extraction and intelligent selection of supply, and with the ultimate goal of safety management decision-making support.

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