Research and Application of Knowledge Decision Method for Optimal and Fast Drilling in Emergency Rescue Wells

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Abstract. The efficiency of coal mine emergency rescue work is limited by the professionalism of decision-making, the efficiency of rescue team formation and the rate of resource mobilization. Knowledge sharing and inheritance have important reference meanings for improving the efficiency and success of rescue work. In order to improve the efficiency of rescue work, this article builds a knowledge base that meets the needs and research on key content\textsuperscript{[1]}. This article first analyzes the knowledge engineering, knowledge representation and knowledge storage of emergency rescue well drilling; secondly, based on the analysis of the emergency rescue well work flow, it classifies the knowledge of fast drilling, and studies the knowledge expression based on ontology\textsuperscript{[2]}. Construct the ontology model of knowledge and establish the knowledge base; then, in view of the shortcomings in the current knowledge retrieval, apply the full-text search to the retrieval of the fast drill-in knowledge, construct the retrieval model and design the index structure of the knowledge base, on this basis The ranking of knowledge retrieval is optimized. Finally, combine the retrieved knowledge and follow the emergency rescue process to form a set of decision-making plans. Through the application of the case study in this article, it is shown that the standardized management of the knowledge of excellent and fast drilling in emergency rescue wells is realized, the speed and quality of the acquisition of knowledge of excellent and fast drilling are improved, and the efficiency and professionalism of decision-making are improved.

1. Introduction

Knowledge decision-making is one of the important links in the construction of smart oilfields. The application of new technologies in the field of information such as knowledge base and full-text search technology to drilling will help promote the realization of smart drilling. Zhang Junbo and others analyzed the organizational characteristics of coal mine emergency rescue, divided the coal mine emergency rescue into 4 parts, established a coal mine emergency rescue organization structure model, and abstracted it into a network to calculate the efficiency of the emergency rescue organization. Cao
Shugang et al. The correlation analysis method in the system theory establishes the evaluation model of the optimal index system for coal mine safety production. Song Haojie and others have studied the application of the knowledge base system in the field of military technology by analyzing the current management status of China’s military technology, and built an Ontology’s military technology knowledge base, and proposed a knowledge retrieval mechanism that combines ontology semantics with user attributes.

In recent years, in order to achieve optimal and fast drilling and improve decision-making efficiency and professionalism, Chinese drilling companies have begun to widely adopt some modern information management technologies\[3\]. Knowledge engineering is an emerging subject used to study the acquisition, representation, management and application of knowledge, providing theories and techniques for the realization of knowledge base management systems. Knowledge engineering can convert domain knowledge, including book knowledge, electronic documents, expert experience, etc., into a computer-recognizable format and store it in the knowledge base. Through knowledge retrieval and knowledge reasoning, engineers and technicians can effectively use this Knowledge. Experts have accumulated a lot of experience and information in long-term production practice. By combing and summarizing this knowledge, a knowledge base of excellent and fast drilling can be formed, which can effectively improve the efficiency of expert acquisition of knowledge, thereby reducing the drilling cycle and improving Scientific and professional decision-making.

2. Excellent and fast drilling into the knowledge base construction

2.1. Knowledge Classification

The knowledge base is constructed by the content-based knowledge classification method and the representation-based classification method: the content-based knowledge classification can divide the excellent and fast drilling knowledge into drilling industry standard knowledge, experience knowledge, equipment knowledge, document knowledge, and technology [4].

Representation-based knowledge classification can divide knowledge into factual knowledge such as experts, extremely equipment, papers, etc., and conceptual knowledge that requires reasoning such as drilling decisions, formulas, axioms, etc.; when used, decision makers are more inclined to use You can process and use knowledge with your own thinking, so you can use the processing method of factual knowledge to process conceptual knowledge, that is, "factualization" of conceptual knowledge, which is essentially the use of plain text to record conceptual knowledge.

2.2. Knowledge expression based on ontology

2.2.1. Ontology construction method tools

Expression method: ontology representation, advantages: strong expressive ability, flexible representation,

Representation language: OWL ontology representation language. Advantages: Semantic definition can be carried out, logical relationship expression ability is strong, compatibility is strong, and the ability to express knowledge understood by the machine is strong [5].

Modeling tool: Protege, advantages: support for exporting multiple ontology formats, installable plug-ins, built-in multiple ontology reasoning engines, ontology models can be automatically sorted and merged, and the interface is visualized.

In order to improve the formula calculation ability of the ontology, this paper designs an assignment expression based on the OWL ontology languages SWRL and SQWRL. Its basic form is shown in formula 1. Here it is called the xm expression. The four parts are:

\[
\text{after:}\{\text{query}\ ?\ 0\ \text{S} + \text{1}\}\ 
\]

Leading character: used to determine the execution timing of the expression. There are currently two types: before and after, which respectively represent the execution of assignment statements before and after the inference engine performs inference.
2.2.2. Ontology model construction
Analyzing the knowledge of fast drilling in emergency rescue wells, the main body can be divided into
two categories: the ontology of fast drilling and the ontology of experts. Establish the ontology model
and use the triple database as the storage method of ontology. The ontology model is shown in Fig. 1.

![Ontology model of optimum fast drilling](image)

2.2.3. Knowledge acquisition
This article uses manual and semi-automated methods to complete knowledge acquisition. The manual
acquisition method is that experts summarize and summarize the existing knowledge information and
convert it into a computer-recognizable format to add to the knowledge base. Semi-automatic knowledge
acquisition The method refers to the system providing a certain knowledge editing interface to help
experts complete the induction and summary of knowledge, thereby adding knowledge to the knowledge
base.

3. Excellent and fast drilling knowledge retrieval method

3.1. Full text search
The basic idea of the full-text search method is to extract the information in the full-text data (plain text
data) and reorganize it to structure it, and then search the index (structured information is called "index").
The construction process of full-text search is shown in Fig. 2. The construction steps are: first collect
text, perform text conversion, then build an index, then perform user interaction, and finally sort the
retrieval.

A full-text search system refers to a system that can index full-text data, perform full-text search and
data management.

![Full text search](image)

3.2. Search establishment
Due to the different structure of the data in the knowledge base, it is necessary to analyze the data
structure and express different types of knowledge in an unified manner. The attributes of various
types of knowledge in the establishment of an index model are shown in Fig. 3. The composition of the
index model can use the formula:

\[ I = \{ ID, IF, DS, LO \} \] (2)
Where: ID refers to the ID attribute of the model, IF refers to the retrieval attribute collection of the model, DS refers to the description attribute collection of the model, and LO refers to the positioning attribute collection of the model.

Through the analysis of the search model of optimum fast drilling knowledge and the attributes and types of the knowledge model, the unified search model attributes are determined as: ID, title, click-through rate, adder, adding time, content, label, category, type, size, update times, and score. The type is used to identify which kind of knowledge the knowledge item belongs to. The positioning attributes of the model are ID and type. The retrieval attributes include title, content, label, and category. The description attributes include adding time, adding by, and size. Click-through rate, number of updates, and rating.

3.3. Sorting and optimization

In full-text retrieval, the sorting algorithm is determined on the basis of the retrieval model, and its basic form is as follows. Among them, represents the weight of the i-th term in the query sentence and represents the weight of the document term.

\[ \sum q_i \cdot d_i \]  

(3)

In this model, both documents and search terms are assumed to be part of an n-dimensional vector space, where n is the number of index terms. A document is represented as a vector of index items:

\[ D_i = (d_{i1}, d_{i2}, d_{i3}, \ldots, d_{ij}) \]  

(4)

Which represents the weight of the j-th term. A data set containing n documents can be expressed as a matrix of term weights. Each row in the matrix represents a document, and each column represents the weight of the corresponding document on the relevant term. The matrix can be expressed as:

\[
\begin{array}{cccc}
\text{Word}_1 & \text{Word}_2 & \ldots & \text{Word}_n \\
\text{doc}_1 & d_{11} & d_{12} & \ldots & d_{1n} \\
\text{doc}_2 & d_{21} & d_{22} & \ldots & d_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
\text{doc}_n & d_{n1} & d_{n2} & \ldots & d_{nn}
\end{array}
\]

(5)

The query statement is expressed in the same way as the document, that is, the query statement can be expressed as a vector with n weights:

\[ Q = (q_1, q_2, \ldots, q_j) \]  

(6)

Which represents the weight of the j-th term in the query sentence.

The query terms and documents represented in this way can be represented as points in n-dimensional space, where each term is the coordinate axis of the space, and the weight of the terms in the query term and the document is the value on the corresponding axis. Fig. 4 takes three-dimensional space as an example to illustrate. Based on this representation, the closer the document to the "query point" is, the higher the relevance and the higher the ranking.
Fig.4 Vector representation of documents and queries in 3D space

Among the algorithms for calculating the similarity between documents and queries, the cosine similarity algorithm is the most widely used. It uses the cosine value of the angle between the document and the query as a measure of similarity. The calculation formula is as follows:

$$\cos(D_i, Q) = \frac{\sum_{j=1}^{l} d_{ij}q_{ij}}{\sqrt{\sum_{j=1}^{l} d_{ij}^2 \sum_{j=1}^{l} q_{ij}^2}}$$

(7)

In formula 7, the algorithm is divided into two parts: tf and idf. The product of tf and idf is used as the weight of the term. Among them: tf represents the frequency of a term in the document, and its formula is:

$$tf_{ik} = \frac{f_a}{\sum_{j=1}^{l} f_{ij}}$$

(8)

Which represents the number of occurrences of term k in the document, and represents the frequency of term k in the document.

idf refers to the inverted document frequency, used to reflect the importance of the term in the document collection. The formula of idf is as follows, where N is the number of documents in the document collection, which is the number of documents containing the term k.

$$idf_k = \log \frac{N}{n_k}$$

(9)

4. Conclusion

a) This article establishes a knowledge base based on drilling knowledge and historical case data, covering drilling manuals, case data of rescue wells over the years, and machine tool parameters. This model provides engineering guidance for improving decision-making efficiency.

b) In order to improve the decision-making efficiency of the optimal and fast drilling plan for emergency rescue wells, the use of knowledge base analysis to build a knowledge model can provide a theoretical basis for making decision-making more efficient and professional.

c) The knowledge base system established in this paper, based on the analysis of knowledge, combined with the analysis of the full-text retrieval model, provides new ideas and solutions for the knowledge decision-making of drilling optimal and fast drilling.

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References

[1] Li Pengchong. Research and Application of Institutional Repository Retrieval System Based on Domain Semantics. Beijing: Beijing University of Posts and Telecommunications, 2015.
[2] Nian Zhigang, Liang Shi, Ma Fanglan, et al. Research and application of knowledge representation methods[J]. Application Research of Computers, 2007, 24(5):234-236.

[3] Wang Weizhong. Technical analysis of emergency rescue and emergency avoidance in coal mines[J]. Automation Application, 2020(09):138-139.

[4] Chang Yimeng. Analysis on emergency rescue management technology for coal mine accidents[J]. Science and Technology Wind, 2020(23): 190-191.

[5] Cheng Huiping, Chen Yongchao. Research progress of domestic knowledge retrieval[J]. Library and Information Service, 2011, 55(10):126-129.

[6] Tang Xiaobo, Zhai Sharpe. Research on Knowledge Retrieval Based on Ontology Knowledge Collection[J]. Research in Library Science, 2018(1):60-66.