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Design and Implementation of Jess Based on Intelligent Diagnosis System Paper

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Abstract—This paper introduces how to achieve a Jess-based intelligent diagnosis system of local ventilation in the mine field, analyzes how to add rules engine Jess into the development of intelligent diagnosis system, at the same time, it leads the theory of statistics into the inference engine to achieve the reasoning under uncertainty, to reduce the gas explosion in coalmine accident and to improve the security of ventilation with positive significance.

***Keywords**- diagnosis system; Jess; reasoning under uncertainty; fact base; inference engine*

Introduction

Mine ventilation is a security measure for mine production, and it has a direct influence on mine production and security management. At the same time mine ventilation is a common effective measure to manage gas, fire and dust disaster. This includes the levels of management and technique and is the key to promote coal mine security. Poor ventilation may lead to gas explosion, fire, etc. In recent years, gas explosion happens continually in China and has caused many deaths and loss of properties. Ordinary production is affected. According to survey by State Administration of Work Safety, nearly one third of the accidents are related to poor ventilation of coal mines. Therefore, it is urgent to promote underground ventilation ability.

This article is based on maintenance service for underground ventilation. According to the present knowledge on failure and past maintenance cases, based on rule engine Jess developed by Java, a diagnosis system is developed to propose intelligently suitable repair plan for the recognition of failure reasons with the help of part of failures. At the same time when knowledge is used to solve problems, the original knowledge can be modified and extended, and new knowledge is obtained, thus achieving the function of automatic machine learning. In the knowledge base maintenance module, records of repair and newly-added rules are arranged artificially and are put to knowledge base, thus the knowledge base is extended and updated. Intelligent digital safeguard is provided for underground security

I. INTRODUCTION OF JESS

Jess is a rule engine and scripting environment written entirely in Oracle's Java language by Ernest Friedman-Hill at Sandia National Laboratories in the United States of America in 1995. Its powerful scripting language gives you access to all of Java's APIs. Jess is small, light, and one of the fastest rule engines [1] available. This article carries out research on the application of Jess in mine ventilation.

Jess uses an enhanced version of the Rete algorithm [2] to process rules. Rete is a very efficient mechanism for solving the difficult many-to-many matching problem. The Rete algorithm is designed to sacrifice memory for increased speed. this uses much of the memory. Jess provides some orders to sacrifice some functions to reduce in-memory usage rate. But in fact, the contradiction between in-memory and function is not clear. Even a large program can satisfy the setting [3] of 64M of default heap in Java.

Jess applies production rule as the basic knowledge representation. And the core includes fact base, rule base and inference engine . Among these inference engine is composed of pattern matching, conflict set, execution engine [4]. Rule base and fact base compose knowledge base. Once fact in fact base changes, the inference engine will carry out pattern matching and add rule that match antecedent and fact to the conflict set. This step is the key based on rule reasoning and determines the inference efficiency of inference engine. The execution engine activates rules in the conflict set and modify fact base according to certain priority level. Repeat the process until unchanging inference ends in fact base. Fig.1 shows the structure of Jess with clarity.

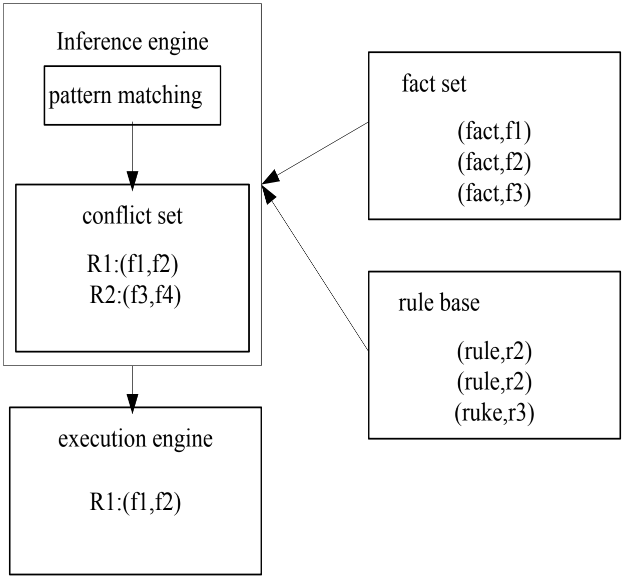

Figure 1. structure of Jess

II. IMPLEMENTATION OF KNOWLEDGE BASE SYSTEM

A. *Representation of knowledge*

Natural language is the commonest way of representing knowledge. But natural language is ambiguous and fuzzy, so knowledge represented by it is difficult to manipulate on computer. Therefore, knowledge representation that can be recognized by computer must be found, and this is the question that knowledge representation deals with [5]. At present, the common knowledge representation methods in artificial intelligence include predicate logic representation, produce type representation, the framework representation, semantic network representation and process representation, etc. They play an important role in the representation, description, storage, usage, acquisition, retrieval of knowledge. As for specific question, effective knowledge representation is important for the solution.

The predicate logic representation is mainly used in automatic theorem proving, problem solving field. Knowledge represented by this method is easy to understand and has a strict definition. But this method lacks in organization, so knowledge base represented by this method is difficult to manage and is not suitable to show the procedural and enlightening knowledge.

Knowledge represented by production rule is simple in form and easy to understand and interpret. Rules are independent from each other . Clear structure makes it easy to extract knowledge formalize it. But the mutual influence and impact between rules decrease efficiency of problem solving.

Framework method to represent knowledge benefits inference. But in reality there are many prototypes that do not suit framework method.

Semantic network can show the relatedness between entities. It is unnecessary to traverse the whole knowledge base to get the related fact from joining knot. But this cannot guarantee the effectiveness of the conclusion got from net manipulation. There are no standard terms and conventions in net expression. The explanation of semantics entirely depends on net programs.

Case representation does not represent meta-knowledge. It represents cases. It mainly includes description of the initial condition of problems and the actual solutions [5].

Through analysis of many repair cases for underground ventilation system failure, combined with Jess features , this system applies production rule and framework to describe knowledge.

- Representation by production rule

When describing a question by natural language, we suppose when failure D happens, A, B, or C will happen. We often say "Failure D exists when A, B, or C appears.". In knowledge base, rules are used to store this logic [6]. When the sentence is transformed into a rule, the logical form is

$(A \wedge B) \vee C = D$ or if $(A \wedge B) \vee C = D$ then D

In the above, $(A \wedge B) \vee C = D$ is the LHS part of the rule or antecedent. D is the RHS part of the rule or the consequent.

Jess stores all rules in rule base in the following form:

defrule r(A)(B)=>(D)
defrule s(C)=>(D)

- Framework knowledge

In the system framework knowledge[8] is mainly used to describe phenomena and conclusions in the repair plan and the related statistical data, i.e. to store data for the rule to manipulate. Jess uses facts to store this type of knowledge. In Jess, facts are divided into three types: ordered, unordered and object facts. Each fact corresponds to one template and each template is composed of a name and a series of slots. In fact, a template can be regarded as a table. Template name is the table name and the slot name is the attribute name. According to the template, a fact will get its name and a series of slot tables.The construction of template may uses deftemplate structure[8].

The system defines two templates for framework knowledge. Node template describes the current situation of repair cases and solutions. Data template describes the statistical information related to cases, i.e. The times that different phenomenon appears in the same case. And this is a preparation for the following inference in uncertain situations.

(deftemplate node (slot name) (slot type) (slot bug1) (slot bug2) (slot bug3) (slot bug4) (slot conclusion))

(deftemplate data (slot name) (slot data1) (slot data2) (slot data3) (slot data4) (slot data5))

B. *knowledge acquisition Maintaining*

According to the features of repair case knowledge for underground ventilation failure, artificial acquisition and automatic acquisition are integrated and applied.

- Artificial acquisition

Artificial acquisition of cases is the edit of repair records provided by maintenance workers.That is, phenomena and conclusions of repair cases are recorded and then are saved in the fact base as facts in the form or node template. Every maintenance worker must add a repair record to the system according to given form after each maintenance. When the administrator manages the knowledge base, the system standardizes information in fact base and save it in knowledge base. At the same time the system learns the knowledge automatically and updates the original data.

- Automatic acquisition

Automatic acquisition of knowledge mainly updates statistical data about the relativity between different faults in knowledge base. This acquisition depends on a large training set which is composed of a large number of maintenance cases. In learning process two types of facts are updated, that is, data-facts that record the number of appearances of different phenomena in the same case and global variable that records the total number of appearances of phenomena.

III. IMPLEMENTATION OF INFERENCE ENGINE

A. *inference method and strategy*

With knowledge representation and acquisition method, the next step is to design the key part in the system: inference engine and algorithm, that is, method to process knowledge and algorithm to solve problem[9].

The method of inference in the system is deduction. Deductive inference is reasoning from general to special and this suits this project that aims to reach conclusion from phenomena. The forward and backward inference is used in the strategy [10]. Forward inference provides system with useful facts for users. Backward inference allows the system to raise questions to users according to situation in the process of inference, thus strengthening target and smoothing the inference.

When inference engine runs, forward inference is used at first to match rules, that is, to infer according to phenomena provided by users. In Jess, forward inference finds rules of LHS that match facts in the rule base and then infers the part of RHS. The specific inference process is introduced in the first section. But when phenomena provided by users are not enough to infer (rules cannot be activated), backward inference is needed. In fact Jess does not support backward inference, but forward inference can be used to simulate backward inference. The following is an example.

When a rule exists, it is first declared that backward inference can be carried out:

(do-backward-chaining fact3)

(defrule oil circuit breaker)

(fact1 pull rod moving or fracture)

(fact2 oil drain all but no-taking steps and stopping power)

(fact3 oil deterioration or mixture water)

=>(answer oil circuit breaker broken and burning)

Thus description of the phenomenon by users is obtained and rule is activated and inference ends. If users cannot react to phenomenon, this needs inference under uncertainty in the next section.

B. Implementation of inference under uncertainty

Part of inference is how to infer useful results from incomplete data. In actual application, when fault description provided by users is not enough to activate LHS of the rules, inference under uncertainty is needed. Inference under uncertainty in this system makes use of statistical model of language in the field of parsing (Markov model).

In nature, pattern matching is carried out for the LHS part of rules. And LHS is formed through linking after Boolean calculation of several faults. This shows that statistical theorem can be used to analyze relations between faults and inference under uncertainty can be reached.

Suppose s is a string of ordered words q_1, q_2, q_3. To put it differently, s is a Boolean representation after Boolean calculation of several faults. At present, from a certain perspective, the inference is how to get the most possible matching rule for s and possibility in the condition when faults are not enough to activate LHS. This is the probability of s in Mathematics, represented as p(s). By the formula of conditional probability, the probability of s sequence is equal to multiplication of the probability of each word, so p(s) can be extended as:

$$p(s) = p(q_1)p(q_2 \mid q_1)p(q_3 \mid q_1q_2)...p(q_n \mid q_1q_2...q_{n-1})$$

In the formula, $p(q_1)$ is the probability of the first word q_1; $p(q_2 \mid q_1)$ is the probability of the second word given the first one; and the like. It can be seen that qn is determined by the word before it. From the viewpoint of calculation, every possibility exists and calculation cannot be implemented. So according to Markov model, suppose the probability of any word q_i is only related to the word before it q_{i-1}. So scale of inference is decreased without influencing inference accuracy. Now the probability of S is changed to:

$$p(s) = p(q_1)p(q_2 \mid q_1)p(q_3 \mid q_2)...p(q_i \mid q_{i-1})$$

The following problem is how to estimate $p(q_i \mid q_{i-1})$. According to conditional probability, we can get $p(q_i \mid q_{i-1}) = p(q_i \cap q_{i-1}) / p(q_{i-1})$

To calculate this formula needs support of many training texts, that is, many maintenance cases. When many cases are obtained, the problem becomes simple. Now it is necessary to calculate the appearances of $p(q_i \cap q_{i-1})$ and q_{i-1} in the maintenance cases. And the vale of conditional probability can be computed.

We have a simple example:

LHS part of a certain rule W is $a_1 \wedge a_2 \wedge a_3 \wedge a_4$, and users only provide description of three faults a_1, a_2, a_3. The three descriptions are not enough to help users find matching rule in rule base. Now faults provided by users should be extended according to probability.

In the fact base of Jess, for each fault, occurrences of the fault that takes place together with other fault and its total occurrences are recorded. Now compare all $p(a \mid a_i)$, and we can get the fault phenomenon a_i with the highest probability.

Boolean calculation is then carried out for the fault phenomenon obtained above and the faults provided by users. We can get $a_1 \wedge a_2 \wedge a_3 \wedge a_4$,

The probability for the Boolean representation is

$$p(s) = p(a_1)p(a_2 \mid a_1)p(a_3 \mid a_2)p(a_i \mid a_3)$$

If p(s) is larger than the previously-set threshold, then the extension is acceptable. This reaches the aim of fuzzy inference according to probability.

IV. CONCLUSION

There is no doubt that in the following years intelligent digital processing plays an increasingly important role in mine security. This system is based on Jess. Platform nonrelativity of Java and multithreading mechanism guarantee that Jess and other programs can be executed together. Operations on shared web data are also guaranteed by Java's synchronous mechanism.

This gives the system powerful network communication capacity and promotes flexibility of the system. Statistics is introduced to the system. A large number of training cases are needed to support the accuracy, but inference under uncertainty is increased greatly.

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