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Procedia Engineering 15 (2011) 1021 – 1029

Procedia Engineering

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Advanced in Control Engineering and Information Science

Ontology- Based Knowledge Management System and Application

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Abstract

By constructing a framework of knowledge management system based on ontology, this paper expounds the function of each layer, and analyses the implementation of this system from the knowledge organization and expression and knowledge retrieval. Finally, it provides a case which implements the management system and realizes some parts of retrieval modules. This management system establishes a sharable ontology that can be understood both by human and computer, which people can found more relations of different concepts through a better circumstance of knowledge retrieval interface. In addition, the system is also open to some extent, so it can accumulate tacit knowledge constantly and polymerize explicit knowledge efficiently, which can lead to a better management and application of knowledge, to support the innovation for the designers.

Selection and/or peer-review under responsibility of [CEIS 2011]

Keywords: knowledge management; ontology; knowledge organization and expression; knowledge retrieval

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doi:10.1016/j.proeng.2011.08.189

1. Introduction

With the rapid development of information technology and practical application of advanced concepts, a variety of tacit, explicit, structured and unstructured knowledge is growing exponentially. How to effectively collect and sort these complex, diverse and multi-domain knowledge and, how to retrieve and reuse them reasonably to create new values for improving the competitiveness of enterprises. Therefore, the development of knowledge management (KM) technologies is arising.

Ontology is a shared conceptual model of the formal specification [1]. Ontology-based knowledge management system is better at supporting the integration of related resources, searching the accurate knowledge qucikly, and avoiding a large number of irrelevant knowledge. Currently, knowledge management has been applied to some large enterprises, such as the United States NIST knowledge base project [2], the European WIST engineering knowledge management projects [3], as well as some domestic knowledge management theories, as proposed by Wujiang,which is a structured framework of knowledge management system [4],Ye Ronghua also proposed an ontology-based knowledge management system [5], all of which have achieved a certain degree of knowledge of effective identification, acquisition, storage and sharing, but not completely enough. In addition, there is a common effect that the dynamic level of participation is not enough, knowledge of access and maintenance of the system is closed, and they can not be better for making breakthroughs and innovation.

This paper builds a framework of a knowledge management system based on ontology, through knowledge acquired from mining knowledge, then organize and express knowledge with the ontology, so that establish a shared ontology can understand both by human and computer, people can found more relations of different concepts through a better circumstance of knowledge retrieval interface. This not only reflects the innovation of knowledge, and it also use tools of management to make sure the preservation and updating of Innovation knowledge timely. This management system has certain openness, so it can accumulate tacit knowledge constantly and polymerize explicit knowledge efficiently, which can lead to a better management and application of knowledge, to support the innovation for the designers.

2. Ontology-Based Knowledge Management System

The most fundamental function of KMS (Knowledge Management System) is to achieve knowledge sharing within an organization. Therefore, acquisition of knowledge is not only the beginning of the Knowledge Management, but also the most fundamental requirement [6]. In order to be convenient for the reuse of knowledge, KMS establishes clear items--which are stored in a knowledge base that contains various structured, semi-structured and unstructured information. The KMS is divided into three parts for the purpose of function realization mentioned above. They are acquisition of knowledge, storage of knowledge, and reuse of knowledge and the whole process, whose core notion is ontology, is linked by knowledge mining, knowledge representation and knowledge connection. The framework of ontology-based KMS designed is shown in Fig. 1.

Acquisition of knowledge is the abstracting process based on the concept of ontology. The process converts all the necessary knowledge, semi-structured and unstructured information to structured information. What's more, acquisition of knowledge is realized by knowledge mining which enables to put knowledge sources, such as various data bases, documentations, and applications and Web est., in the knowledge base after they are dealt with by Knowledge Discovery System (KDS). Other knowledge sources, such as information in all kinds of forums, feedbacks of users (containing tacit knowledge), are firstly put in the transit depot. After sorted out effectively by managers, these sources will be put in the

knowledge base. Therefore, Acquisition of knowledge is the process of knowledge construction rather than knowledge conversion.

Aiming at converting semi-structured and unstructured information to structured knowledge and putting them in the knowledge base, storage of knowledge is the process that the metadata is extracted from knowledge sources acquired above and knowledge objects are marked in virtue of ontology and metadata standards [7]. Ontology base contains relations of the classified concepts of domain knowledge objects and other concepts in a system. Metadata, which KMS requires, is put in the metadata base which is the key tool to search knowledge objects efficiently. Data base and knowledge base are a sort of aggregate of semantic metadata information and relations of knowledge objects. Separated stratum control on related knowledge in virtue of metadata base and ontology is not only the premise but also the foundation to achieve efficient search and speculation on knowledge.

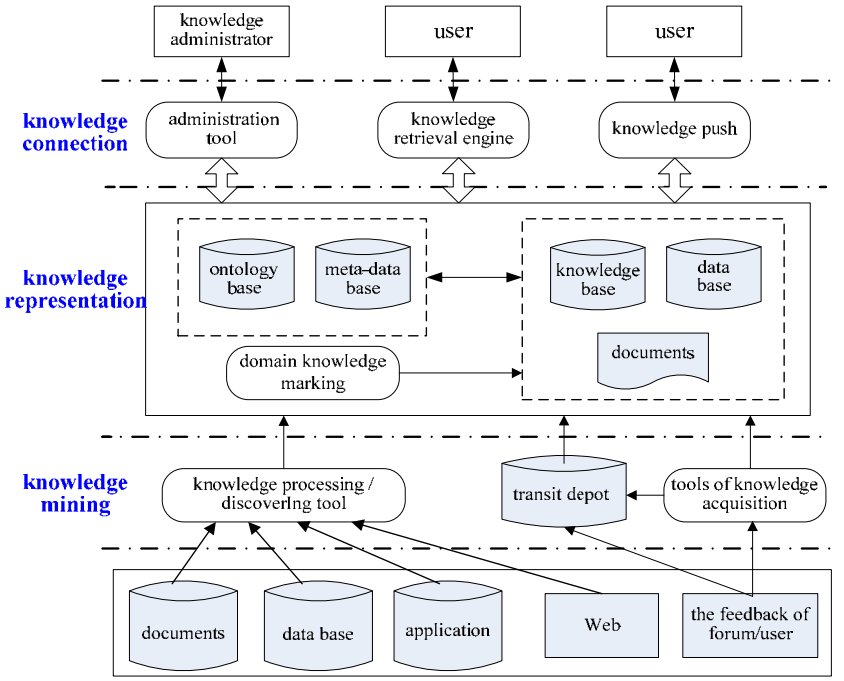

Fig.1. Ontology- based knowledge management system framework

Reuse of knowledge, acquired by knowledge connections, is the process that knowledge is used in application systems. In this part, users can make use of knowledge search engine to find related contents in different separate strata, in other words, ones can acquire knowledge by the method of pull. Moreover, KMS also forwardly offer related knowledge according to personal preference and immediate requirements. Under the condition of friendly management interface, knowledge in the base is regulated, renewed and saved in time by knowledge managers, which enables that systems have qualified ability of dynamic participation instead of ones that are confined to the static usage and close maintenance.

3. Knowledge of Organization and Expression

3.1. Ontology

Ontology is a philosophical category first, with the development of Artificial Intelligence; it has been given a new definition by the artificial intelligence community. At present, it has been generally accepted that Studer [8] gave the definition that ontology is a shared conceptual model of formal specification.

In the view of practice, it is usually adopts five-body-array to describe ontology: concepts or class, relations, functions, axioms and instances [9]. Relation is the soul of ontology in five-body-array. Constructing a good related domain ontology base is the core of the knowledge management base on ontology.

The relations of ontology reflects the constraints, contact or a new relationship between concepts, including the synonymous relation, appositive relation, hyponymy relation, composition relation, causality, and noun modified relation[10]etc. Various relations can coherently links every kind of the knowledge node and constitute a network of knowledge relations base on ontology, then it can find out the right knowledge node through relative path. This paper will divide the network of knowledge relations into two parts: Main ontology relation, Secondary ontology relation. The former relation is to describe all the terms about specific fields and ontology relations between every term; the later relation is to describe the external terms of other fields connecting the terms of main ontology relations. Using the main and secondary relations can make a good knowledge organization, and also retrieve knowledge efficiently and quickly. It gives an example of motor: a part of relation network is shown in Fig. 2.

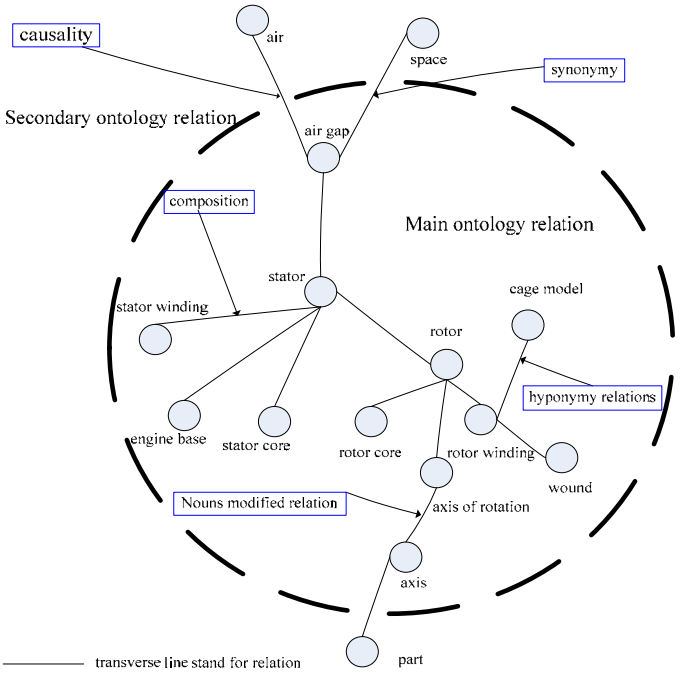

Fig.2. Part of relation network of motor’structure

3.2. Knowledge representation and organization base on ontology

The form of knowledge representation should be placed on the first step. On account of the diversity and complexity of knowledge, it is quite difficult to express the knowledge in structured way. There are many different kinds of knowledge representations by now, but there is no mature and structured method of the knowledge representation at all, what's more, the establishment of a unitary knowledge base can not meet the needs of a mass of innovative designs, because of the cross and integrated knowledge in many fields at present.

This paper puts forward a model of multi-ontology bases about knowledge organization, this model is to establish unitary knowledge base respectively, use the basic characters of ontology and the relations described above that realize the interconnection of multi-ontology bases, and finally form a konwledge network，as it shown in Fig. 3.

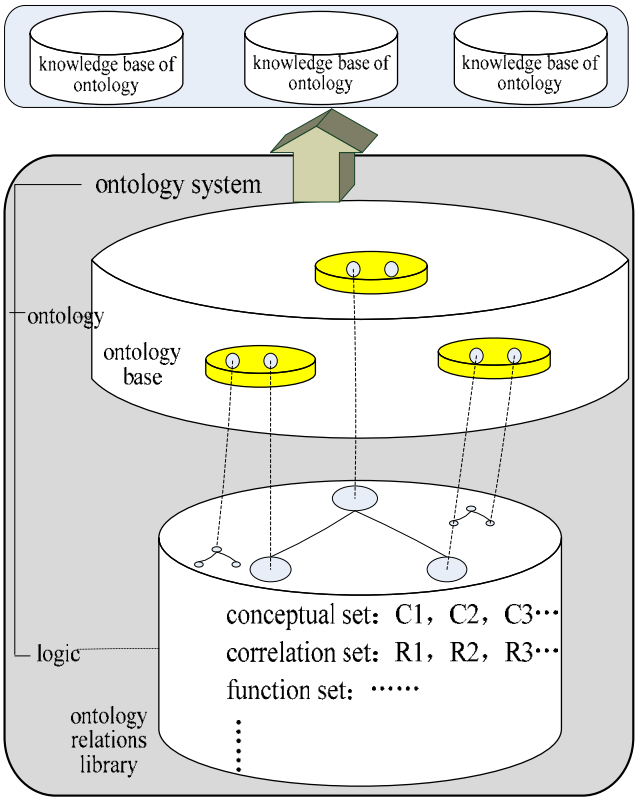

Fig.3. Ontology knowledge organization model

The relation of ontology in logical layer is actually a tree of ontology relations, which exists in the form of structure of a tree. Each concept is the concept of minimum and links to each other by ontology relations. This layer includes all the concepts and relation network of knowledge base. In addition, it includes four elements-properties between each concept: instances, axioms and relations forming relation sets, attribute sets, etc.

Ontology layer is the upper structure of the ontology relations library. Basing on the concept of constructing model of multiple knowledge bases, it formed a knowledge network with the concepts of similar use or supporting the design process (for example, the process equipments, methods, rules in computer aided process planning) and ontology relations linked the function similarity. It is accepted that the each knowledge network is the primary concept sets about related fields and the knowledge network of ontology is the component unit of multi-ontology bases.

In this paper, we can establishe multi-ontology bases with related domain knowledge in terms of constructing logical layer and ontology layer. For instance, it can be divided into several parts like domain knowledge base, principle knowledge base and integrated knowledge base and so on. Every knowledge base of ontology is linked by bottom of restraint between each concept and descripe the object, concept and semantic relation about related areas base on ontology, So as to achieve various design granularity of expression, specifications, integration and sharing.

4. Knowledge Retrieval Base on Ontology

The purpose of the knowledge management is to give the proper knowledge to the right people in order to help them make the optimal decision. Moreover, the knowledge retrieval is a key problem of knowledge management which is the hinge in the connection between people and knowledge. Knowledge retrieval must be based on knowledge organization since retrieval pattern is resolved by organization pattern, and it is the opposite process of the knowledge organization [11]. So this paper uses the domain-ontology-based organization pattern, based on the research of the ontology and the knowledge representation and organization, to design the retrieval mode as shown in Fig. 4.

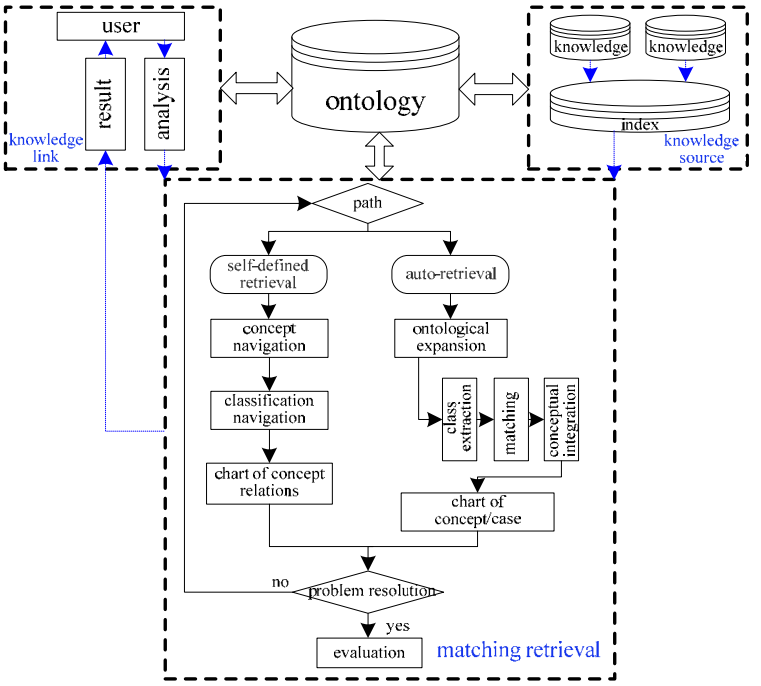

Fig.4. Model of knowledge retrieval base on notology

This retrieval mode is devided into four parts: knowledge interlinkage, ontology, knowledge resources and matching retrieval. Knowledge interlinkage's main function is getting into the matching retrieval process through retrieval passages,choosing the appropriate entrance(self-defined retrieval and auto retrieval) ,which searches the knowledge nodes and concepts in the related fields,obtaining satisfactory matching results and then returning them to the user. Knowledge resources is the foundation of the knowledge retrieval based on the ontology, it is the key point to make the knowledge retrieval system different from other common information retrieval system, further more, it is the core of the system model. From the retrieval analysis and results handling to the knowledge matching retrieval process, to the knowledge resources marking, to the index founding, are all based on the related knowledge in the ontology.

High-efficient knowledge retrieval depends on a high-quality retrieval strategy and method.This paper designs two retrieval paths, self-defined retrieval and auto retrieval, which allows uer in different levels to choose the appropriate retrieval methods according to the different demands. In the process of self-defined retrieval, user can define the aspects of knowledge all by themselves through the concept navigation, classification navigation and the chart of concept relations, since the system will search the related concepts about the standard questions based on the ontology. Ontology is actually a kind of categories, thus, it can illustrate the fluctuation relations of the ontology to the user in the human-computer interaction layer.And the user can select the view of the listed ontology. Because the ontology are specified by user in a certain choosing range,namely the range for searching are narrowed more or less in some degree,therefore,matching the necessary knowledge for the user. This kind of search mode with certain flexibility can largely meet most users' needs and provide users with more directional guidances.

Another kind of retrieval path is automatically retrieval (extended type retrieval), which is actually the expanding of the concepts. It is executed based on the relations between concepts and semantics of the ontology. it contains two aspects as follows:using the relations expressed by the hierarchical structure in domain ontology to generate more retrieval results.User-demanding concepts replaced by "superclass" concepts or the specific attribute value replaced by attribute value, which all reduce the constraints of this retrieval mode. User-demanding concepts replaced by a subclass concept can gain deeper and more semantic concepts and expression forms; using the interdisciplinary concepts, inluding many other fields of knowledge and other fields of concept-relative knowledge, to expand the field which these interdisciplinary knowledge are belonging to.

5. Knowledge Application and Implementation Base on Ontology

We can apply this system to the field of mechatronics, after further study on the establishment of a framework of knowledge management system based on ontology, the knowledge organization and representation, as well as retrieval.

Firstly, in order to mine, sort and construct the related knowledge base, we can use a variety of tools for knowledge acquisition to study on related fields of knowledge. A well designed ontology is the key to build a knowledge management system successfully. This paper clearly defines the hierarchy between vocabularies which are mutually accepted in this field, and adopt the "from top to down" approach, which means listing first top-level concepts, and gradually refining to establish sub-categories. For example, we can divide electromechanics into several classes： enginery, power, driver, performance etc. then gradually spread the sub-categories. Spreadiing by analogy, there may get a conceptual graph that has domain knowledge with relativity; finally construct a notology model after defining the attributes of classes.

The value of ontology konwledge base is application. Therefore, the conncetion between questions that had to be solved and knowledge in base is primary for knowledge retrieval. The model of knowledge retrieval has been told above, if user chooses self-defined retrieval, it will enter the interface, as it shown in Fig. 5.

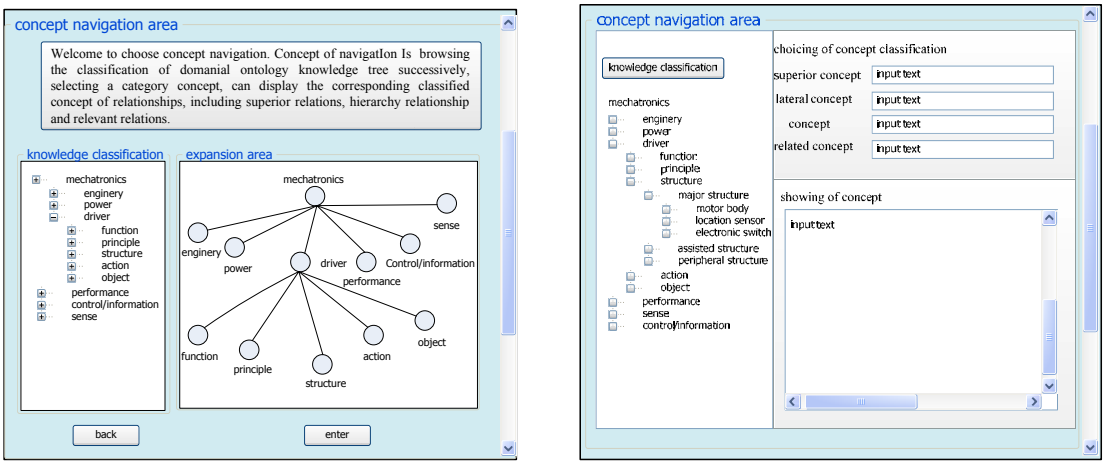

Fig.5. (a) Self-defined retrieval module; (b) Self-defined retrieval module

On the left of concept navigation area is the concept tree showing classes, the opposite side is the chart of network relations. Clicking the button “enter”, it will be shown as Fig. 5(b). Selecting a concept, the right will be display the mian relations of theme concept, including superior concept, lateral concept, concept and related concept that be shown in showing of concept area. This way gives user a narrow or expansion search range so as to obtain corresponding knowledge objects.

If user chooses auto- retrieval, it will enter the interface, as it shown in Fig. 6.

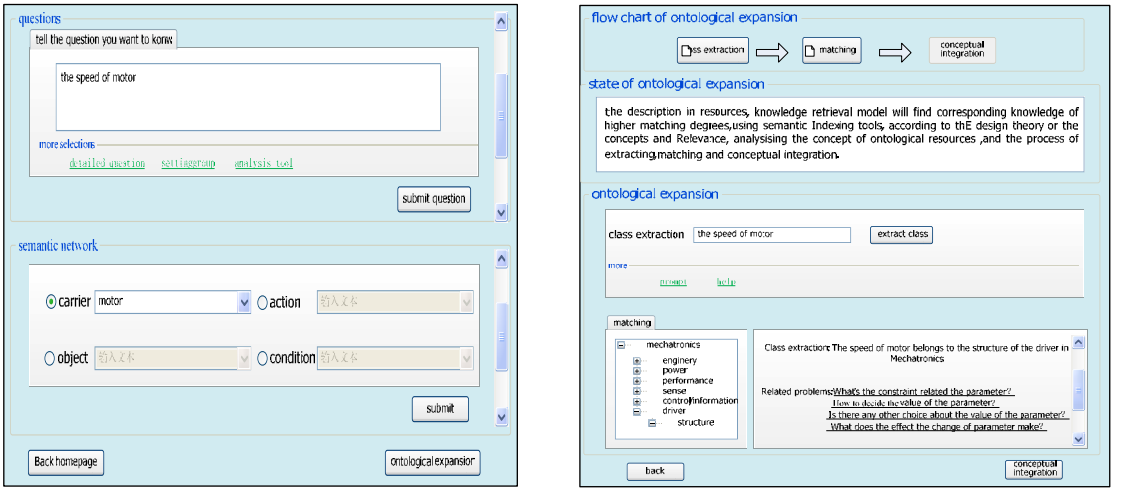

Fig.6. (a) Auto-retrieval module; (b) Auto-retrieval module

Firstly, by divided into four factors: carrier, action, object and condition, using ontology index for inquiring and adjusting ontology term, it will get problem representation. Clicking the button "ontological expansion", user will acquire satisfied kownledge after class extraction, matching and conceptual integration.

6. Summarry

In this paper, the process of knowledge is divided into acquisition, storage and reuse, connecting with knowledge mining, knowledge representation and knowledge link. Ontology is the kernel in the process. We constructed a framework of knowledge management system based on ontology, which make the system realize through in-depth analysis of the knowledge organization and the knowledge retrieval. Basing on better knowledge organization and expression, the system that is partly open realise knowledge retrieval efficiently and quickly. The next step of work will focus on how to acqurie the related knowledge by processing tools and auxiliary means, how to make the ontology modeling in detail, how to processs dynamic management effectively through management tools.

Acknowledgements

This work has been supported by the National High-Tech Innovative design technology and knowledge-based prototype system based on multi-domain knowledge-driven, China (Grant No. 2009AA04Z164), and the key scientific and technological projects of Chendu (10GGYB642GX-023).

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