Journal of Systems and Information Technology

A study on the ontology building methodology for diseases of mind diagnosis

Hyeongi Baek Mun Koo Kang

Received 10 November 2013
Revised 20 February 2014
Accepted 4 March 2014

A study on the ontology building methodology for diseases of mind diagnosis

Hyeongi Baek
The Institute of Mind Humanities, Wonkwang University, Iksan-si, Republic of Korea, and
Mun Koo Kang
Department of English Education, Kongju National University, Gongju-Si, Republic of Korea

Abstract

Purpose – The purpose of this study was to construct a mind counseling ontology to efficiently facilitate the diagnosis of the diseases of mind. To determine the structure of mind counseling ontology, this study conducted analysis on structural forms available in counseling books and other related fields and adopted essential ones in the explanation of counseling. The processing of the diseases of mind was divided into three stages: cause, symptoms and counseling. The stages were analyzed one by one in terms of process, functional elements and relevant technique necessary at each stage.

Design/methodology/approach – In the mind counseling list, there are 12 different diagnoses of diseases of mind that are classified into four classes. Thus, the causes, symptoms, prescription and medical history for 12 diseases of mind are defined as a higher rank concept of mind counseling ontology. The causes, symptoms, prescription and medical history consist of definition, affective characteristics and related factors, while the potential diagnosis consists of definition and risk factor. This information does specify detailed notions in the diagnosis of diseases of mind, but considering the limitation of not being able to represent all the diseases, this study enables a counseling center to give and use individual definitions of diagnostic terminology of their own.

Findings – This study adopted the top-down approach, in which mind counseling ontology defines a higher rank concept, the terminology in diagnosing diseases of mind, based on the list of terms from the counseling record that specifies the abstract concepts of the diagnosis. The bottom-up approach was also incorporated, which defines the diagnostic terms extracted from the counseling record as a subordinate concept of the mind counseling ontology. Thus, the development of the mind counseling ontology involves the combination of top-down and bottom-up approaches to the construction of ontology.

Originality/value – This research has significance in that it deals with the fundamental problem of the mind aiming for a true change and healing of it, which is the ultimate purpose of this ontology, especially in the circumstances where research on ontology in diagnosing the diseases of mind is unprecedented.

Keywords RDF, RDFS, Ontology, Mind diagnosis, Ontology building methodology, OWL

Paper type Research paper

"This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korean Government (MEST) (NRF-2010-361-A00008)."

Journal of Systems and Information Technology
Vol. 17 No. 2, 2015
pp. 102-112

1328-7265
DOI 10.1108/JSIT-11-2013-0059

1. Introduction

The advent of knowledge- and information-based society has accompanied tremendous change in every area of life. The field of education, with which all citizens of a nation are associated, is currently in the center of the torrent of change. Although knowledge-oriented education is thought to be the best possible means to survive in the intense competition, it is also crucial to guide students to build a proper set of values and a positive attitude toward life, considering the fact that proper human education should be the premise of any type of education. A number of teens in the modern society encounter various cases of crisis in the course of developing into independent individuals. Many of these youths say their minds have been hurt by the negative experiences. They try to heal their memories by reviewing the past, attempting to find the underlying reason for "the diseases of mind" in someone else or in their external environment.

In the attempt to understand this "disease of mind", however, one usually arrives at a psychological conclusion based on the framework of self-interpretation or distorts the truth and gives priority to attaining ostensible solutions, consequently neglecting a more fundamental problem, the problem of the mind. Hence, such an approach cannot obtain a change in the whole person. Although information relating the diseases of mind is available in various ways with people's growing demand for the management of the diseases of mind, it is difficult to find information that specifically corresponds to different individuals.

To resolve this sort of problems, this study intends to construct a mind counseling ontology. Ontology refers to a formal and explicit specification of a shared conceptualization within an area of interest. To reinterpret the meaning, ontology defines the rules for forms and use of formal representation methods and explicit concepts so that machines can process them by using consented terms and definitions to identify concepts formed in the relevant field with a particular purpose. Ontology consists of classes, relations, properties, instances and axioms. A simple definition of ontology would be 4-tuple (C, R, I, A). C stands for a set of concepts, and R represents a set of relations. I indicates a set of instances, and A stands for a set of axioms (Ehrig *et al.*, 2005).

The use of ontology allows the facilitation of systematic construction of a large amount of complicated knowledge and makes it available to save the knowledge as meaningful information. It also has benefits of reduction in costs necessary for associated system development, by enhancing integration and inter-operability between different information systems, which are distinct from the past systems that require reinterpretation by an expert's intervention and judgment. Furthermore, ontology is a useful tool for the integration of existing systems for complicated counseling terms, eventually making it possible to offer a client-oriented counseling service by activating reuse and sharing of relevant data. Thus, it is beneficial in that the client has access to the service necessary for himself/herself at the moment.

Therefore, this study attempts to construct a counseling ontology that offers effective information relevant to diseases of mind suitable for the target client.

2. Theoretical background and related research

2.1 The concept of ontology

The term "ontology" is derived from the Greek word "ontos (being)" and "logos (word)". Ontology is originally an area of philosophy which refers to research and study on the types, structures, processes and relations in the beings of the world. Often used as a

synonym of metaphysics, the term "ontology" was first used in philosophy to distinguish itself from ontology in natural sciences.

In a philosophical perspective, ontology is a concept that offers a classification system that explains a certain viewpoint (Hong and Oh, 2010). Sowa (2000) defines ontology as "a study on the category of entities that exist or can exist in a particular area". In this perspective, ontology exists in various types and forms, ranging from simple conceptual classifications like categories in Web portals and a thesaurus, which is linguistically a lexical ontology and to more complicated forms concerning complex concepts and inference rules. Various definitions of ontology were presented in philosophical, logical and linguistic perspectives, but the definition in computing is a more widely accepted one (Gruber, 1993; Borst, 1967; Guarino, 1998).

Gruber (1993) defines ontology as "a formal, explicit specification of a shared conceptualization". This is the most commonly referred definition, which implies the following: "Conceptualization" in ontology means assembling concepts that exist in abstract forms into explicit categories. To be "explicit" means to specifically describe the usage of knowledge and present it in the form of a concept to clearly classify models of phenomenon that exist in abstract forms. To be "formal" means to represent the prescribed terms and relations among the terms able to be processed by a computer. Being "shared" refers to each field commonly using a well-defined concept.

2.2 Components and types of ontology

Ontology is an important method of organizing concepts of semantic technology, which explains the relationship between each consented concept. Mostly, it is formed based on a particular domain, and the meaning of a concept can be used differently according to the domain. The components of ontology are class, concepts, relations and properties (King and Reinold, 2008). "Class" can also be referred to as "concepts" and is an abstract title for an object or a concept in a domain. It is an abbreviation organized in the classification system, which implies the relationship of inheritance and subordinate connotation that are well-defined between concepts through "IS-A" relationship. It also describes the hierarchy of concepts as "whole versus part" relationship among the concepts. "Instances" refer to the actual form of an object or a notion or the actual value of it and possess the property of the concept of inference. "Relations" is the relationship between class and instances. Relations connect non-hierarchical notions and define the implicational relevance among notions.

"Properties" specify the hierarchical structure of the notions and generate, adapt and eliminate the properties of "class". The categories of ontology can be classified into general ontology and domain ontology according to the range of construction, and metadata ontology, Web ontology, representational ontology and task ontology according to the subject of construction (Fensel, 2001). General or common sense ontology encompasses general knowledge and notions of time, space, incidents and states of all entities. Domain ontology includes knowledge appropriate for a particular domain, which is thus ontology of an artifact of a specific form.

Metadata ontology provides a range of vocabulary necessary to describe the contents of online information source, such as Dublin Core. Web ontology, in a broad sense, is a type of metadata ontology, which makes a semantic connection between the tagging of Web language and relevant standards and description method. Representational ontology is an ontology that does not correspond to a certain domain and offers an entity

without any mention about what to represent. Method ontology or task ontology provides information on a particular task, offering standards of judgment on the knowledge of a specific area.

2.3 Representation of ontology

To facilitate the sharing and reuse of information through ontology, the relevant knowledge should be represented in a form comprehensible by computer and humans. The representation system of knowledge that enables flexible understanding and application of a large amount of information in various domains includes semantic network, frame, rules, first-order logic, description logic, etc. Its structure can have influence on the vocabulary of ontological language, knowledge representation models and inference mechanism.

Description logic is a representation language that deals with terminological knowledge by structuring and formally representing knowledge. For instance, the phrase "A man who graduated university and gained acceptance from three companies" can be represented as "Human∩Male∩ ∃ graduate. University∩(≥ gain acceptance Company)". The words "Human" and "Male" represent simple notions, while "graduate" and "gain acceptance Company" indicate the relevance between notions. The signs "∩" and "≥" represent inclusion relationship and are called constructors. Constructors consist of Boolean operators in logics and quantifiers such as "all" and "some".

First-order logic is a way of representing Knowledge Interchange Format (KIF) language used in the representation of ontological knowledge in this study and is also referred to as first-order predicate logic. It specifies a statement by separating each component parts of a sentence. For example, the statement "Charles likes Jane." can be rewritten in the predicate logic as "like (Charles, Jane)". In first-order predicate logic, it is possible to represent various notions using variables and quantifiers. The logic's expressive feature enables the representation of the majority of logical content. Ontological language was formed based on the representation system of knowledge, such as description logic and first-order predicate logic.

Ontological language can be divided into language based on artificial intelligence such as KIF (Genesereth and Fikes, 1992) and F-Logic (Kifer and Lausen, 1989) and ontology markup language such as extensible markup language (XML) (Bray *et al.*, 1998), ontology inference layer (OIL) (Fensel *et al.*, 2001) and web ontology language (OWL) (Dean and Schreiber, 2004; Gómez-Pérez *et al.*, 2003).

2.4 Methodology of diagnosis on diseases of mind

This study refers to the concepts of counseling lists in defining the terms in mind counseling ontology. The terminology used in diagnosing the diseases of mind that are generally defined by a counseling center has been specified by analyzing the terms frequently used in the counseling statements recorded by the former center. Therefore, to represent the diagnostic terms used in the counseling statements as ontological construction, a top-down approach is adopted, in which mind counseling ontology defines a higher rank concept, the terminology in diagnosing diseases of mind, based on the list of terms from the counseling record that specifies the abstract concepts of the diagnosis (Figure 1). Furthermore, this study also incorporates bottom-up approach, which defines the diagnostic terms extracted from the counseling record as a subordinate concept of the mind counseling ontology. Thus, the development of the

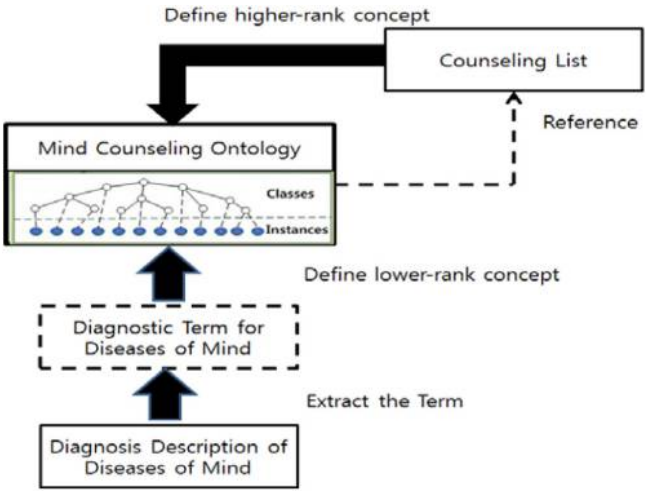

Figure 1.
Methodology of diagnosis on diseases of mind

mind counseling ontology involves the combination of top-down and bottom-up approaches to the construction of ontology.

Ontology defines "concept" and "property", while specifying the relationship between concepts using two concepts and one property. The mind counseling ontology defines concept and property as follows. There are 12 different diagnoses of diseases of mind that are classified into four classes. Thus, the causes, symptoms, prescription and medical history for 12 diseases of mind are defined as a higher rank concept of mind counseling ontology. The causes, symptoms, prescription and medical history consist of definition, affective characteristics and related factors, while the potential diagnosis consists of definition and risk factor. Although this information specifies detailed notions in the diagnosis of diseases of mind, it is not enough to represent all the diseases. Therefore, a well-defined set of diagnostic terminology for each counseling center is required.

To specify the diagnostic terms, the mind counseling ontology refers to the mind counseling list. The mind counseling list is a terminological system in standard counseling, representing the hierarchy of the terms by classifying 18 conditions which counseling terms should comply with. Also, each term is assigned a concept ID (CID) to clearly represent the meaning of the counseling terms, which are used as standard terminology that ensures a mutual operation between hospital information systems (HIS's). When defining a subordinate concept of counseling ontology, the diagnostic terms for diseases of mind are invested with a meaning by referring to the terms used in the counseling list.

In a mind counseling list, it is possible to define and adopt a new concept, using well-defined previously existing concepts. This process is called "terminological axiom" in ontology, which is similar to defining a new concept. All the components of a mind counseling list are represented as concepts, and the concepts that correspond to "properties" in ontology are defined as "linkage concept" in S-counseling list. Thus, to define the "properties" of mind counseling ontology, reference to the concepts of counseling list is necessary.

The terminological system, used as the international standards, has each term and concept assigned a distinct code, through which the ambiguity of the meanings of different terms is resolved. To be specific, a diagnosis of a disease of mind in a counseling list is assigned a 5-digit code, and a concept in the counseling list is assigned a concept code of 6 to 18 digits, enabling the representation of ontological components with distinct codes. On the contrary, counseling ontology represents its ontological components in terms and phrases to portray meaning simply by the denotation of concepts to enhance the readability.

2.5 Design of knowledge model for diagnosis of diseases of mind

Figure 2 shows an example of a construction of mind counseling ontology, according to the previously stated methodology of constructing ontology. More specifically, it defines the structure of higher rank concepts of mind counseling ontology by representing the domain, class and diagnosis in a hierarchical structure, based on the classification of diagnosis of the diseases of mind in the mind counseling list. For example, "risk for injury", which is assigned a diagnostic code of "00035" from the mind counseling list, is defined as a subordinate concept of "safety and protection" – a domain in a counseling list – and "physical injury" – a class in a counseling list.

This complies with the classification system of the counseling list. With regard to more specific diagnostic terms to define diseases of mind that cannot be covered by the terms in the mind counseling list, a new concept is defined, and a subordinate concept structure is formed according to their meaning. In addition, to determine the meaning of new diagnostic terms of diseases of mind, the relationship is formed between the concepts in the mind counseling list. For instance, the concept "mind body at risk for injury" is subsumed under "risk for injury" and possesses the property of "finding site", which is assigned a CID of "363698007" in the counseling list, while forming a relationship with "entire human mind" with the CID of "281189005".

Furthermore, under the concept of "mind body at risk for injury", the concept "human mind at risk for injury associated with melancholia" is subsumed under "human mind at risk for injury" and possesses the property of "associated with" that is assigned a CID of "47429007" and limits its meaning by forming a relationship with "melancholia" with a CID of "387713003". Figure 2 shows the representation of each concept in Figure 1, according to description logic.

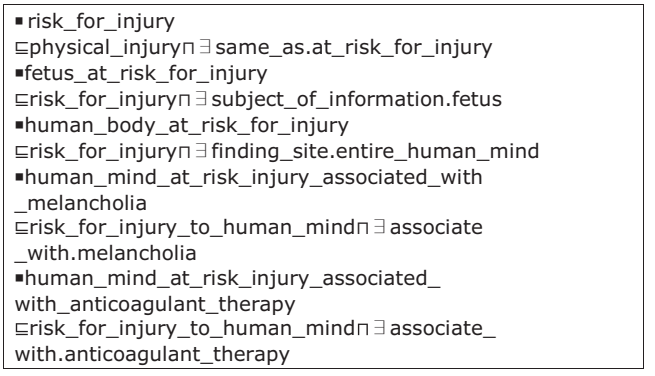

Figure 2.
Representation of ontological concepts in description logic

3. Construction of ontology in diagnosis of diseases of mind

This study intends to construct a mind counseling ontology through a conceptual modeling, by analyzing and classifying relevant data retrieved in the process of counseling. The construction of the mind counseling ontology can be utilized in the counseling management system, which provides meaning-based search and automatized intelligent service. First, it defines the ontological domain by analyzing the counseling process and delineates the class, properties and relationships between classes. After designing, it constructs ontology using OWL – the standard ontological markup language enacted by W3C, using Protege 4.1, an ontology development tool. OWL provides XML terms, possesses inference ability and is capable of representing a variety of relationships.

3.1 Structure of mind counseling ontology

To determine the structure of mind counseling ontology, this study conducted analysis on structural forms available in counseling books and other related fields and adopted essential ones in the explanation of counseling.

The process is divided into three stages: cause, symptoms and counseling. The stages were analyzed one by one in terms of process, functional elements and relevant technique necessary at each stage. The first stage, cause, requires the elements related to the diseases of mind, while the next stage of symptoms is a process of deriving alternatives from numerous thoughts and ideas concerning the disease. Finally, at counseling stage, the proceedings are recorded and the results of counseling are shared. In the series of stages, one can see a systematic connection in cause, symptoms and counseling, with the importance of saving, sharing and extracting various forms of data. Based on this, a domain model is constructed where the process and functions of the domain of diseases of mind are divided into three stages.

It is crucial to determine the range and purpose of the mind counseling ontology in designing an ontology based on accurate analysis on the domain.

3.2 Determination of class, class hierarchy, instances and property

Conceptualization of mind counseling ontology is as explained in Figure 3.

3.2.1 Setting up class and instances. The top-level class is counseling, which includes four sub-classes: cause, symptoms, prescription and identification of disease. The "cause" and "symptoms" of a disease are organized based on the criteria and classification of cause and symptoms provided by counseling materials. The definition of class and class hierarchy of "prescription" is according to the mind counseling list.

3.2.2 Defining property. "Class" systematically organizes the list of concepts, and the relationships among them are defined by the "property." "Property" defined in this study is based on the relationship between each item in the concept map of ontology in the diseases of mind. The relationship by "Protege" is shown in Table I.

3.2.3 Input of counseling knowledge and defining relationships. The cause, symptoms, counseling and individual list of the diseases of mind are entered in "class" and "instance" above, and the relationship between each symptoms and counseling is determined in "instance". The domain and range of each property is defined in advance, making it possible to activate each case under a "class" and to enter the relevant data, as shown in Figure 4.

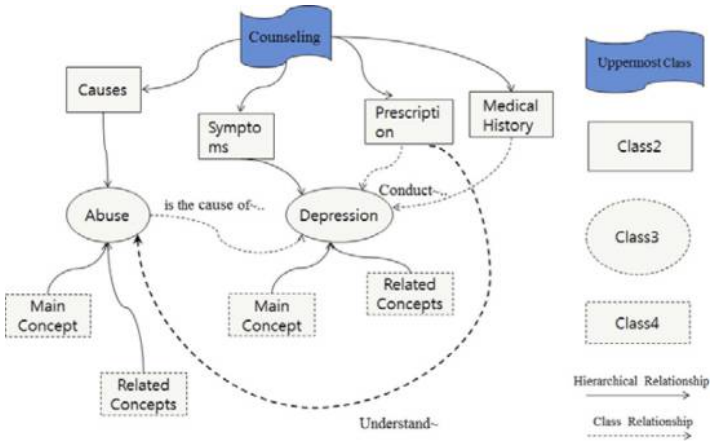

Figure 3.
Conceptualization of mind counseling ontology

Property	Interpretation	Domain	Range	Inverse property
Has cause	Have a cause	Disease of mind	Cause	Is cause of
Is cause of	Is a cause of	Cause	Disease of mind	Has cause
Has pathology	Have a disease of mind	Symptom	Disease of mind	Is pathology of
Is pathology of	Is a disease of mind	Disease of mind	Symptom	Has pathology
Has drugs	Have counseling	Symptom	Counseling	Is drugs of
Is drugs of	Is a counseling method of	Counseling	Symptom	Has drugs
Has prescription	Have a prescription	Counseling	Prescription	Is prescription of
Is prescription of	Is a prescription of	Prescription	Counseling	Has prescription

Table I.
Definition of property

4. Conclusion

This study aims at constructing a mind counseling ontology to efficiently facilitate the diagnosis of the diseases of mind. To determine the structure of mind counseling ontology, this study conducted analysis on structural forms available in counseling books and other related fields and adopted essential ones in the explanation of counseling. The processing of the diseases of mind was divided into three stages: a cause, symptoms and counseling. The stages were analyzed one by one in terms of process, functional elements and relevant technique necessary at each stage.

This study adopted the top-down approach, in which mind counseling ontology defines a higher rank concept, the terminology in diagnosing diseases of mind, based on the list of terms from the counseling record that specifies the abstract concepts of the diagnosis. The bottom-up approach was also incorporated, which defines the diagnostic terms extracted from the counseling record as a subordinate concept of the mind counseling ontology. Thus, the development of the mind counseling ontology involves the combination of top-down and bottom-up approaches to the construction of ontology.

In the mind counseling list, there are 12 different diagnoses of diseases of mind that are classified into four classes. Thus, the causes, symptoms, prescription and medical

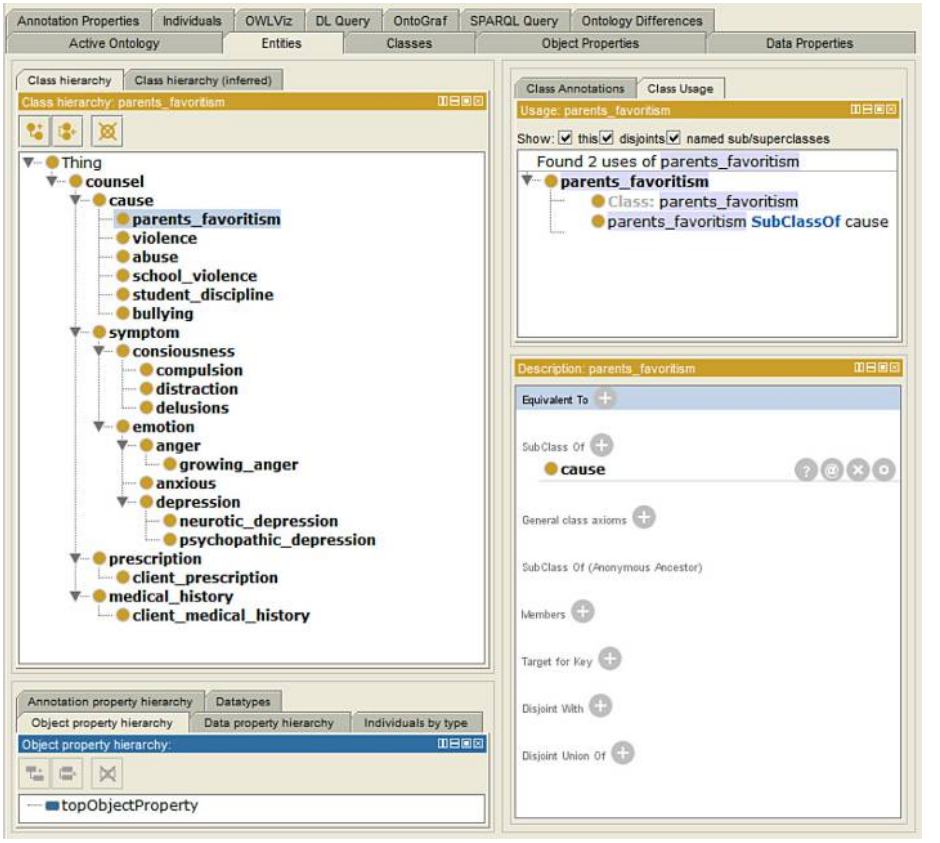

Figure 4.
Input of counseling knowledge and defining relationships

history for 12 diseases of mind are defined as a higher rank concept of mind counseling ontology. The causes, symptoms, prescription and medical history consist of definition, affective characteristics and related factors, while the potential diagnosis consists of definition and risk factor. This information does specify detailed notions in the diagnosis of diseases of mind, but considering the limitation of not being able to represent all the diseases, this study enables a counseling center to give and use individual definitions of diagnostic terminology of their own.

This research has significance in that it deals with the fundamental problem of the mind aiming for a true change and healing of it, which is the ultimate purpose of this ontology, especially in the circumstances where research on ontology in diagnosing the diseases of mind is unprecedented. However, the research faces its limitation in that the development of ontology for diagnosis of the diseases of mind made it so far as the planning and designing stage and that it has not verified the efficiency and validity of the ontology developed. Such limitations are thought to be supplemented and resolved in the subsequent future research by interviewing clients and consulting with experts responsible for diagnosing actual diseases of mind.

References

Borst, W. (1997), "Construction of engineering ontologies for knowledge sharing and reuse", *PhD thesis*, Centre for Telematica and Information Technology, University of Tweenty, Enschede, NL.

Bray, T., Paoli, J. and Sperberg-McQueen, C. (1998), "Extensible markup language (XML) 1.0", W3G Web document, available at: www.w3.org/TR/REC-xml

Dean, M. and Schreiber, G. (Eds) (2004), "OWL web ontology language reference", W3C Recommendation.

Ehrig, M., Haase, P., Stojanovic, N. and Hefke, M. (2005), "Similarity for ontologies-a comprehensive framework", *Proceedings of 13th European Conference on Information Systems, in a Rapidly Changing Economy (ECIS)*, Regensburg (DE).

Fensel, D. (2001), *Ontologies: Silver Bullet for Knowledge Management and Electronic Commerce*, Springer, Berlin.

Fensel, D., Harmelen, F., Horrocks, I., McGuinness, D. and Patel-Schneider, P. (2001), "OIL: an ontology infrastructure for the semantic web", *IEEE Intelligence System*, Vol. 16 No. 2, pp. 38-45.

Genesereth, M. and Fikes, R. (1992), "Knowledge interchange format-version 3.0 reference manual", Technical Report Logic, 92.1, Computer Science Department, Stanford University.

Gómez-Pérez, A., Fernández-López, M. and Corcho, O. (2003), *Ontological Engineering. Advanced Information and Knowledge Processing Series*, Springer, Heidelberg.

Gruber, T. (1993), "Toward principles for the design of ontologies used for knowledge sharing", *International Journal Human-Computer Studies*, Vol. 43 Nos 4/5, pp. 907-928.

Guarino, N. (1998), "Formal ontology and information systems", *Proceedings of the First International Conference (FOIS'98)*, IOS Press, Trento, June 6-8, pp. 3-15.

Hong, I. and Oh, C. (2010), "Ontology research for developing integration system of human-oriented geographic information", *Korean Cartographic Association*, Vol. 10 No. 2, pp. 139-148.

Kifer, M. and Lausen, G. (1989), "F-logic: a higher-order language for reasoning about objects, inheritance, and scheme", *ACM SIGMOD Conference on Management of Data*, ACM, New York, NY, pp. 134-146.

King, B.E. and Reinold, K. (2008), *Finding the Concept, Not Just the Word: A Librarian's Guide to Ontologies and Semantics*, Chandos Publishing, Oxford.

Sowa, J. (2000), *Knowledge Representation: Logical, Philosophical, and Computational Foundations*, MIT Press.

Further reading

Grobelnik, M. and Mladenić, D. (2006), "Knowledge discovery for ontology construction", in Davies, J., Rudi, S. and Paul, W. (Eds), *Semantic Web Technologies*, Wiley, Chichester, pp. 9-27.

Kim, S.K. (2007), "Using description logic and rule language for web ontology modeling", *Korea Intelligent Information System Society Conference*, *Seoul*, 18 May, pp. 277-285.

About the authors

Hyeongi Baek, HK, is a Professor at The Institute of Mind Humanities, Wonkwang University, and an Assistant Professor in the Division of Interdisciplinary Studies in the Humanities Department. Hyeongi Baek has a PhD degree in educational technology from Jeonbuk National University.

Mun Koo Kang is a Professor at Kongju National University; a Major in English education and English grammar; and Vice President of The English Teachers Association in Korea (ETAK). Mun Koo Kang is the corresponding author and can be contacted at: kangmunkoo@hanmail.net