

"Ontology": A Tool for Managing Domain Module in an Intelligent Tutoring System

Salisu Muhammad Sani, Teh Noranis Mohd Aris, Norwati Mustapha, Nasir MD Sulaiman

ABSTARCT - The intelligent tutoring systems (ITS) is the most recent alternative advancement to human tutors in the teaching and learning processes in today's educational environments that started over the past three decades. The main goal of an ITS is to help students to achieve maximum learning gain and improve their skills acquisition in a particular domain. For an intelligent tutoring system to be very effective in accomplishing these tasks, the system must be equipped with an explicit representation of the domain knowledge that is the subject of the learning activity (Domain model). But the task of acquiring and designing an effective domain knowledge representation is always challenging and difficult that has been the main concern of so many research projects in the fields of ITS and other artificial intelligence (AI) domains.

Keywords: Ontology, Domain Knowledge, Artificial Intelligence, Domain Concepts, Intelligent tutoring systems (ITS).

Salisu Muhammad Sani

Teh Noranis Mohd Aris

Norawati Mustapha

Nasir MD Sulaiman

Department of Computer Science
Faculty of Computer Science and Information Technology
University Putra Malaysia
43400, Serdang, Selangor Malaysia

I. Introduction

Over the past three decades, a number of research projects in the fields of ITSs have focussed primarily on how to deal with the problems of extracting and representing domain knowledge models in the tutoring systems. Ontology, defined as the formal explicit representation of terms and their relationships in a domain has been employed by so many researchers in the field of ITS to manage domain knowledge conflicts [1]. In this contemporary world where knowledge has become a vital asset to most information systems, the need for effective management of knowledge is very apparent for the survival of those systems. The use of ontology as a technology for designing and managing domain knowledge has continue to gain wider acceptance and popularity in different areas such as AI and laboratories that are controlled by domain experts. A major advantage for using ontology as an effective formalism to handle domain concepts and their relation is to provide a common vocabulary for ontology designers to be able to share information with uniform semantics in any domain of discourse [11]. Nowadays, ontology is commonly used to formalize knowledge in the ITSs simply because it describes a conceptual model of a domain, that is, it represents objects, concepts and other entities that are believed to exist, and relations among them. The main structural elements of the conceptual model are the concepts and relations. Consequently, every area of human endeavour can be presented with a set of properly related concepts that correspond to appropriate domain knowledge [2].

II. RELATED LITERATURE

A. An Overview of Ontology

The idea of using ontology in most environments that are controlled by domain experts is to provide an extendable and shareable framework that captures a common vocabulary;

common in the sense that both humans and software systems have the same interpretation and encoding. The power of ontology rests with its ability to provide explicit representation of knowledge (as concepts, properties, and constraints); to encode semantics (as relations, meta-data, and inference); and to allow for a shared understanding of the represented formal knowledge within and in-between humans and machines [10]. An ontologically represented knowledge base is made up of two parts: a terminology box (TBox), which contains terminology axioms (concepts and role descriptions), and an assertions box (ABox), containing individuals (concept and role instances). The Semantic Web community has developed a formal language for ontology implementation called Web Ontology Language (OWL). To develop ITSs that teaches a particular concept, one must not only specify the experts' conceptualizations of the domain, but also clarify how problem-solving will ideally occur. In fact, to be able to follow the learner's reasoning and to provide relevant suggestions and explanations, such ITSs must have knowledge of the domain that is both robust and explicit [12].

B. Types of Ontology

The following three types of ontology are discussed in the literature; the domain specific ontology, the upper ontology and the generic ontology.

a. Domain-specific Ontology

Domain-specific Ontology is geared towards modeling a specific domain, which is a representation of the part of the world entities. Particular semantics of terms used in such domains are virtually defined by the domain ontology. To describe the situation with examples, consider the word "card" that has many different semantics for instance. Ontology about the domain of a "Banking sector" would model the word card to mean an "ATM Card", a "Credit Card", and a "Master Card" etc. In the domain of "Computer hardware" the word "Card" can be modelled using semantics like "Network Card", "Punch card", or "Video Card". Depending on the expressivity of ontology, different kinds of components of domain ontology like properties, concepts, instances or axioms can also be defined [5]. If we consider the concepts as one of the key components of the domain ontology for example, they can be defined in various ways such as:

- By textual expressions. For example, the concept "man" can be defined by the sentence "a male human being".
- By a set of well-defined properties: for example the concept "man" can be defined

by such properties like "name", "date of birth", "address" etc.

- By logical expressions that can be made up of several logical formulae for example the concept "man" can be defined by the formula "living entity" \cap "sensible entity".
- Expressing concepts by set of instances that belong to it. For example "Nelson Mandela" is an instance of the concept "man".

b. Upper Ontology

This ontology is sometimes referred to as foundation ontology; it models mostly the objects that are commonly applied to domain ontology with wide range of application area. It usually contains a general glossary that has entities and descriptions that are associated with the objects of those entities and how they are applied in various relevant sets of domains. Foundation ontology can be seen as Meta ontology that describes the higher level concepts or primitives that are often used to describe other ontology [4].

The Generic Ontology

This type of ontology combines features of both upper and domain ontology. Since domain ontology represents concepts in very specific and often eclectic ways, they are often incompatible. As systems that rely on domain ontology expand, they often need to merge domain ontology into a more general representation. This presents a challenge to the ontology designer. The generic ontology is design in such a way that expressions in one language variant can easily be translated in any other language variant for which a generic dictionary is available. It makes an explicit distinction between the language independent concepts and the terms or phrases with which the concepts are referred to in different contexts or language communities [5].

C. Benefits of Using Ontology

- To share common understanding of the structure of information. Everyone agrees that the terms of the ontology describe the domain of knowledge and the explicit relation that exist among the domain entities.
- Smooth interoperability, when interfacing between two or more domains with different components, they can access the ontology of each component to design a mapping between different concepts in the different domains.
- Ease of web surfing (on-line search). The meta-knowledge within ontology can

assist an intelligent search engine with query processing. For example, if a query returns no results, then the ontology could be used to automatically generalize the query to find nearest partial matches.

- Facilitates re-use of domain knowledge. Why waste time and money rebuilding component X when X already exists in someone else’s library?
- It may be faster to build new systems via “ontological bootstrapping”, in other words, use of conceptualizations in ontology can help in structuring the knowledge in a new domain.

III. Domain Modeling using Ontology

A. Description of the Domain Concepts

In this section, we try to explain how our approach uses ontology to model the domain knowledge concepts in the domain of “Computer System”. To implement our ontological design to this domain, we defined 15 concepts that are believed to exist in the domain of “Computer System” and we will apply the 15 knowledge concepts in our ontology design. These 15 domain concepts are part of over 70 concepts that are taught by an adaptive AC-Ware Tutor system [7]. Students can be able to interact with this adaptive AC-ware Tutor that has ontological domain knowledge, as well as, the ability to administer knowledge tests to students and record each student score. This enabled the realization of the instances of actual student’s knowledge before and after knowledge test, as well as enabling us to understand the conceptual relation that exist between the domain concepts.

Table 1 Part of the Domain Knowledge Concepts for Computer System

Concept Kx
Computer
Central Processing unit
Working Memory
RAM
ROM
Central Processing Unit
Control Unit
Arithmetic Logic Unit
Arithmetic Operation
Logical Operators
Addition
Subtraction
Disjunction
Conjunction
Negation

B. Domain Knowledge Ontology

Domain knowledge ontology is a representation of how the domain concepts relate to each other. To explain how the concepts in our ontology structure relate (Figure 2), we define the direction of the relation between the concepts using the terms subset and superset. Therefore it is important to define clearly how each concept in the ontology is associated with another and what type of relation exist between them, and this allow us to put up the following definition:

Let $K_{CON} = \{C_1, C_2, \dots, C_i\} \ i \geq 0$, be a set of domain concepts, let a set of relations be $K_{REL} = \{R_1, R_2, \dots, R_j\} \cup \{\text{has_superset}, \text{has_subset}, \text{has_instance}\} \ j \geq 0$. Let \emptyset_K denotes an empty set. We now define our domain knowledge concepts K_x to be a combination of triplets (C_1, R, C_2) that show how the relation R describes type of relationship existing between concepts C_1 and C_2 . This relation allows us to say that concept C_1 is a superset of concept C_2 ; similarly concept C_2 is a subset of C_1 .

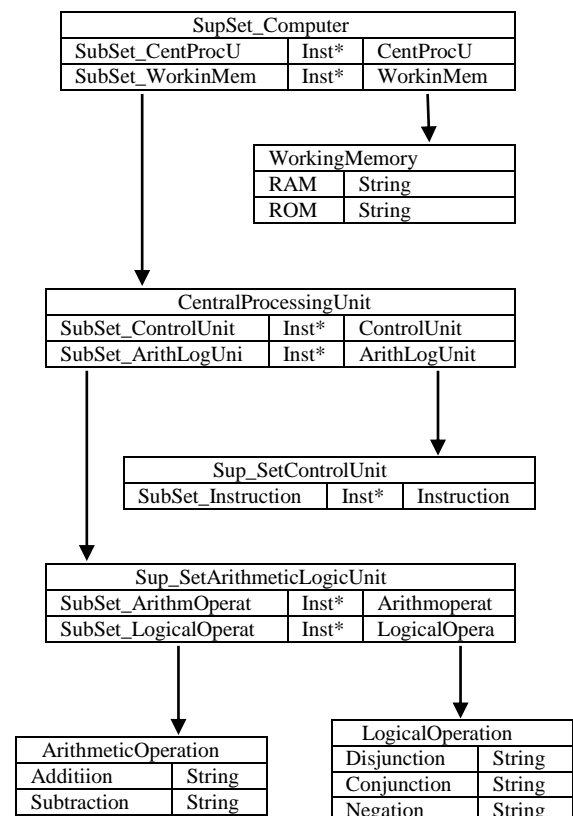


Figure A simple Ontology structure for the concepts in Computer system domain

Conclusion

Based on the outcome of this research, we may have reason to say that ontology is undoubtedly a good tool for representing propositional knowledge and providing shared domain descriptions for various purposes. Looking into the literature of the research, it is possible for the reader to find several definitions of ontology. These are evidences of how important ontology is to various domains of human endeavours. It is obvious then to conclude that ontology provides a comprehensive formalism that removes any ambiguity in communication between software and human agents. Ontology as a tool therefore proved to be an effective alternative for knowledge representation not only in the field of Artificial Intelligence but in so many diverse areas. The domain knowledge structure we developed in this article too justify how ontology can help in modeling one of the vital components of an Intelligent Tutoring System, the domain model.

References

- [1] T. Gruber, "A Translation Approach to Portable Ontology Specification" *Knowledge Acquisition* 5: 199-220. (1993).
- [2] A. Grubišić, S. Stankov, I. Peraic, "Ontology based approach to Bayesian student model design" *Expert Systems with Applications* 40 (2013) 5363–5371
- [3] C. Roussey, F. Pinet, M. Kang, and O. Corcho "An Introduction to Ontologies and Ontology Engineering" *Springer-Verlag London Limited* 2011.
- [4] D. Gasevic, D. Djuric, V. Devedzic, "Model Driven Architecture and Ontology Development" *Springer-Verlag, Berlin Heidelberg New York* 328p. (2006).
- [5] P. van Renssen "Gellish A Generic Extensible Ontological Language" *Published and distributed by: DUP Science ISBN 90-407-2597-4*. 2005.
- [6] Y. Feng-Jeng "The Ideology of Intelligent tutoring Systems" *acm inroads Vol. 1 No. 4*, 2010.
- [7] A. Grubišić, S. Stankov, M. Rosić, B. Žitko, "TEx-Sys model for building intelligent tutoring systems" *Computers & Education* 51 (2008) 1017–1036.
- [9] M. Nieto "An Overview of Ontologies" *March* 2003
- [10] V. Kumar, C. Gress, A. Hadwin, P. Winne, "Assessing process in CSCL: An ontological approach" *Computers in Human Behavior* 26 (2010) 825–834.
- [11] Natalya F. Noy and Deborah L. McGuinness *Ontology Development 101: "A Guide to Creating Your First Ontology"* online (2001).
- [12] R. Nkambou "Modeling the Domain: An Introduction to the Expert Module" *Advances in Intelligent Tutoring Systems, SCI 308*, pp. 15-32 *Springerlink.com Springer-Verlag Berlin Heidelberg* 2010.