DOMAIN MODULE DESIGN: AN ONTOLOGICAL APPROACH

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Abstract

In the contemporary world, knowledge is considered as a vital asset. Every aspect of human endeavour can be represented by collection of well-defined associated entities that can have the same semantic representation especially when dealing with concepts in a particular domain of knowledge. One of the effective tools of Artificial Intelligence (AI) that is commonly employed to formalize such domain knowledge concepts and their relation in the design of an intelligent tutoring system (ITS) is ontology. In Artificial Intelligence field, the term ontology is defined as a representation of the entities in a domain and the way those entities relate to each other. The technique is widely used in the development of AI applications to model the concepts in a particular domain of knowledge, in other words, ontology is employed to represent concepts, classes and attributes that commonly exist in a particular domain and their relationships.

Keywords: Ontology, Domain Knowledge, Artificial Intelligence, Concepts, Intelligent tutoring systems

1. Introduction

In any modern organization, knowledge is a vital asset. Thus maintaining an organizational knowledge has become almost a necessary thing in order to enhance organizational well-being and operations. Ontology as a formal specification of entities and their relationship, continue to play an important role in almost every aspect of human endeavour especially in the development of Artificial-Intelligence applications [1]. Ontology concepts are used in expressing how a set of well-defined entities within an appropriate knowledge domain are related to each other. The description of domain knowledge concepts using ontology provides the means for declaring knowledge formalisms using much simpler tools that can improve the way concepts and relations in a particular domain are managed. The intelligent tutoring system is a computer based system developed using the techniques of artificial intelligence comprising of ontology, Fuzzy logic, Bayesian networks, genetic algorithms, data mining, neural networks etc, that provide adaptive and personalized tutoring to students based on their cognitive states, styles of learning or characteristics [2]. The ITS as an integral system is made up of four basic components namely; the student module, the tutor module, the domain module as well as the interface module. The component of this ITS that represents the domain knowledge concepts and the relation among those concepts is called the domain module. This module therefore, represents a key component of an intelligent tutoring system. If the domain module is not effectively designed to the extent that it expresses how the domain concepts are related, then all the decisions of the other components of an ITS that depend on this module are going to be of poor quality.

1.1 Architecture of an ITS

The intelligent tutoring system is an integral system made up of four basic dependent components namely the domain module, the tutor module, the student module and the interface module [17] (Figure 1). An ITS as a knowledge based system, uses the domain module to manage the relationship between the domain entities.

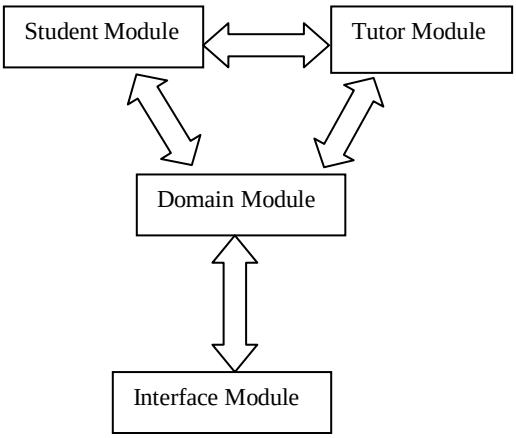

Figure 1 Architecture of an ITS

2. Related Literature

2.1 History of Ontology

The use of ontology in information systems has over the past decades grew and continues to gain more popularity especially in various fields of artificial intelligence such as multi-agents systems, natural language processing, database integration etc. Researchers in the field of AI were originally able to borrow the term "ontology" from Philosophy and from there the word continued to be used in several other areas [3]. From the Philosophical point of view, ontology enables the study of nature of being, their existence and the reality of those fundamental parts of beings and their relation. The use of ontology in the context of Artificial Intelligence was intended to serve as an alternative to knowledge representation [8].

2.2 Types of ontology

The following are the types of ontology discussed in the literature:

2.2.1Domain-specific ontology

This type of Ontology is geared towards modeling a specific domain, which is a representation of entities in the universe of discourse. Such semantics of entities used in that universe of discourse are virtually defined by the domain ontology. To describe the situation with examples, consider the concept "card" that can take various semantics for instance. A representation of the concept card in the universe of "Banking industry" would model the word card to mean an "ATM Card", a "Credit Card", a "Master Card" etc. Similarly, if we consider the universe of discourse for "Computer hardware" the same concept "Card" can be modelled using semantics like the "Network Card", the "Punch card", the "Video Card" [10]. 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 "concepts" as one of the key components of the domain ontology for example, they can be expressed in various ways such as; using linguistic expressions for example the linguistic term "man"can be represented by the linguistic statement "a male human being". Another expression for "concepts" can also be made by using a collection of well-defined characteristics, here the term "man" can be defined by such common characteristics or properties like "name", "date of birth", "address" etc. Sometimes we can express concepts in a particular domain by logical expressions that can be made up of several logical rules, in this case, the entity "man" can be expressed using logical rules, and for example, our entity "man" can be represented by a logical rule "living entity"∩"sensible entity". And finally domain concepts can be expressed using entities and their instances, for instance "Abraham Lincoln" is an instance of the entity "man".

2.2.2 Upper ontology

The upper ontology is sometimes referred to as foundation ontology; it models mostly the objects that are commonly applied to domain ontology with large application. This kind of ontology is commonly characterized by a general

vocabulary 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 is sometimes seen as Meta ontology that describes entities in higher categories that are often used to describe other ontology [4].

2.2.3 The Gellish ontology

Gellish ontology combines features of both domain specific ontology and foundation ontology. Because domain-specific ontology represents entities that are more precise, they sometimes appear to be incompatible to work with. But more and more systems relying on domain ontology are emerging, thus the need to integrate domain ontology with additional representations to make it more general become apparent. Ontology designers are therefore faced with more challenging tasks to satisfy this requirement. Gellish ontology is designed with the capability to transform a variation from one language to another using a Gellish dictionary. It provides a mechanism to distinguish between concepts that are independent and those entities whose conceptual representations are defined in different contexts or linguistic term [5].

3. Domain Model Design

3.1 Description of the Domain Concepts

At this stage, we try to explain how our approach uses ontology to model the concepts in the domain of "Computer as a system". To implement our ontological design to this domain, we defined 73 concepts that are believed to exist in the domain of "Computer as a system". These 73 domain concepts are believed to be the concepts learnt when students interact with an adaptive AC-ware Tutor system [7]. The advantage of using the AC-ware Tutor system is to enable us to get instances of student's knowledge after testing by the system (the student module) as well as enabling us to define the conceptual relation, the ontology that exist between the domain entities.

Table 1 Part of the domain knowledge concepts

Concept Kx
Application software
Arithmetic operation
Arithmetic-logic unit
Assembler
Basic
Basic Computer function
C
Capacity
Central unit
Central processing unit
Compact disc
Compiler
Computer system
Computer
Conjunction
Control Unit
Data entry
Data processing
Data storage

3.2 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 $K_{CON} = \{M_1, M_2, ...M_i\}$ $i \geq 0$, be a set of domain concepts and let a set of relations be K_{REL}={M1,N2,.....Nj}U{has_superset,has_subset ,has_instance} $j \geq 0$. Let $Ø_K$ denotes an empty set. We now define our domain knowledge concepts Kx to be a combination of triplets (M_1, R, M_2) that show how the relation R describes the type of relation that exist between concepts M_1 and M_2. This relation allows us to say that concept M_1 is a superset of concept M_2; similarly concept M_2 is a subset of concept M_1.

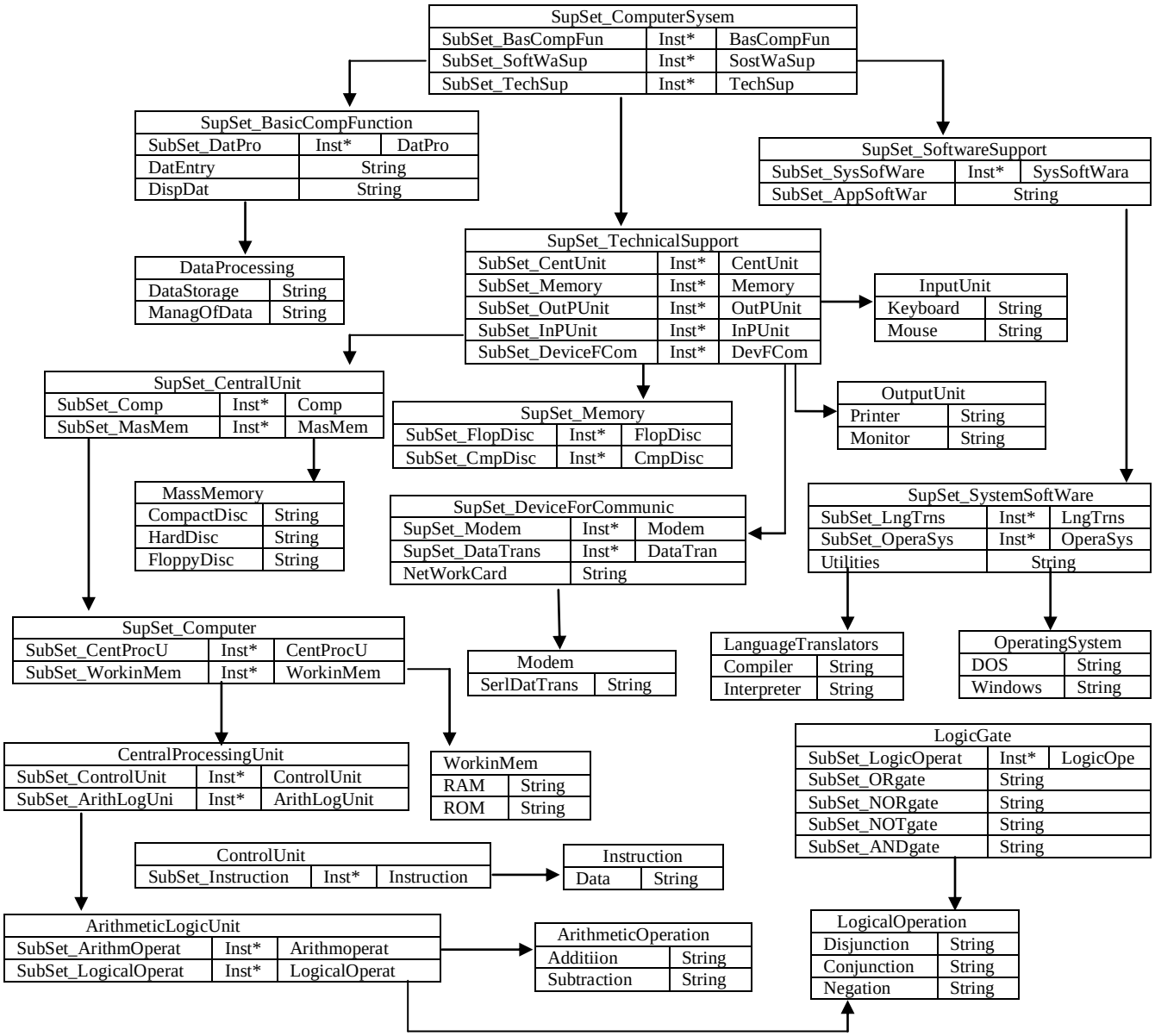

Figure 2 the ontology structure for the domain concepts

4. Conclusion

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] Gasevic, D., Djuric, D., Devedzic, V. "Model Driven Architecture and Ontology Development", 328p. *Springer-Verlag, Berlin Heidelberg New York (2006).*

[4] C. Roussey, "An Itroduction to Ontology Engineeribg" Springer-Vergal. London Limited. 2011.

[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 inrods 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*

[8] J. Li. "An Educational Tool for the Ant Colony Optimization Algorithm", *First International Workshop on Education Technology and Computer Science, 03/2009*

[9] Z. Jingyi, Y. Lv, "An approach of refining the merged ontology", *2012 9th International Conference on Fuzzy Systems and Knowledge Discovery, 2012.*

[10] C. Chao, "An Affective Learning Interface with an Interactive Animated Agent", *IEEE Fourth International Conference on Digital Game And Intelligent Toy Enhanced Learning, 2012*