ISSN 1870-4069

Ontology: Components and Evaluation, a Review

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Abstract. The ontologies are a powerful tool for representing the knowledge from a particular domain so it is necessary to know its elements in order to guarantee the safety and satisfaction of the task for which was designed and created. This work presents a general review of the elements and evaluation of the ontology in order to offer practical definitions and some ontology application examples.

Keywords: Ontology, ontology's elements, ontology evaluation.

1 Introduction

All days the peoples generate a big information amount to share on the Internet, since a text message until the personal location. Sometimes there are problems when we want to consult, sort or transfer this information because the format is not the same in all sources. The ontology has the purpose of providing knowledge for data structuring by rules mainly on the web, from a particular domain.

We can define the ontology as a formal abstraction of what we wish to represent of a domain, using specific information such as objects, properties, and relationships [11] by a structure normally of hierarchical type; Tello [32] defines ontology as an explicit and formal specification about a shared conceptualization, that has a defined and legible vocabulary to express the main concepts and relationships about a specific domain [24]. The ontology also can be defined as a form of representation about a particular universe of discourse or some part [19], it has a well-defined structured from a set of most representational terms with human-readable text description and its construction methodology depend on clarifying what types of objects are researched in that domain [5].

In general, we can say that the ontology is a theory that specifies a relative vocabulary into a domain in order to help with the semantic interoperability among systems mainly in the web [18]. There are many kinds of ontologies according to their focus, application, creation, the specific domain, and generics [30].

In this work, the elements and evaluation techniques of an ontology are described in offering a general view about semantic knowledge representation and its evaluation from two approaches: validation and verification, and based on criteria.

This work is structured as follows: in section 2, it describes the main elements which forming an ontology; section 3 contains evaluation techniques based on two approaches; section 4 contains the related works about the ontology application and finally, section 5 contains the conclusions and future work.

2 Ontology's Elements

The ontology can be seen as a 5-tuple where its components are: Concepts, relationships, functions, individuals or instances and axioms [32].

$$Ontology =< C, R, F, I, A >, \tag{1}$$

where:

- **Concepts (classes):** are the main formalized elements of the domain [32]. Since the logic, the concepts can be described using specific properties which must be satisfied by them [2].
- **Relationships:** are links between the concepts for representing the ontology structure (taxonomic or not taxonomic).
- **Functions:** are elements with the purpose of calculating information from the other elements.
- **Instances (objects):** are the representation about the main objects within domain according to ontology structure.
- **Axioms:** are the restrictions, rules, logic correspondences definitions [4] which must be accomplished in the relationship between the ontology elements. The axioms can be seen as the smallest unit of knowledge within an ontology [31].

Then, we can see an example of ontology about relevant information about the Master's degree in Computer Science (see Fig.1), where there are three taxonomies: Investigation Line, Person and Subject; a case of taxonomic relation is Student is-a Person [22] [26].

3 Ontology Evaluation

The ontology is a very important tool for the information representation that has become a standard for the knowledge representation [13], so it is necessary to evaluate its main aspects in order to guarantee that representation to be the most real according to the domain. The evaluation of an ontology can be seen from two approaches: verification and validation [1], or evaluation by criteria (see Fig.2).

3.1 Verification

The verification is used to determine if the ontology is correctly constructed or not by the satisfaction of the competency questions which was defined as part of the proposed task, i.e., if the built ontology is suitable for the real world. The verification has the next focus:

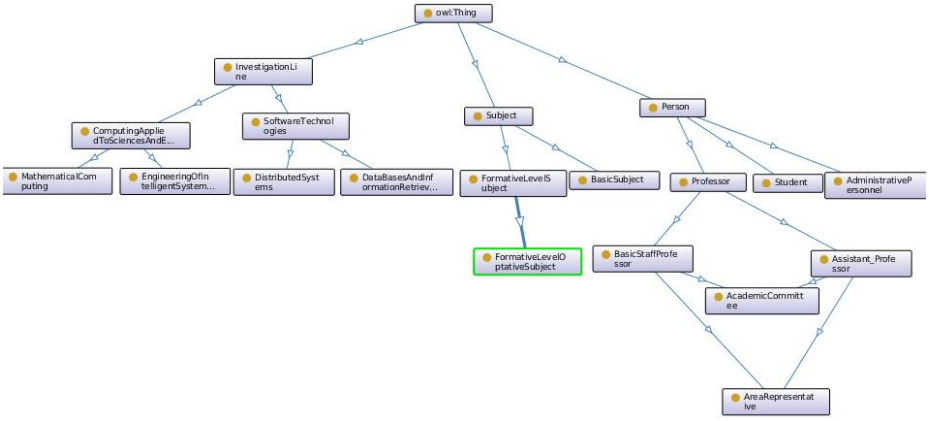

Fig. 1. Ontology Example: Master's degree in Computer Science.

- **Lexical:** the lexical verification is related to the vocabulary used for conceptualizing the domain and is regularly made with precision, recall and F-measure [31] [3]. This verification includes aspects related to the reusability [15].
- **Taxonomic:** specifically, this verification is only focused on is-a and has-a relationships within the ontology.
- **Semantic:** is based on consistency by the semantic features of the ontology [37] considering the meaning and content of these features [15].
- **Context:** can be evaluated by other web ontologies or specific applications [28] which are in the same domain.
- **Syntactic:** this verification is about the coherence in the ontology definitions [28]. For a deep verification, it is necessary using some criteria [15].
- **Structural, architectural and design:** have the purpose to identify the absence of the main concepts of a domain in the structure, loops, concepts with the same definition but different name, among other errors. In this kind of verification does not exist metrics well defined because could be ambiguous [37] and normally the metrics are context-free [8].

3.2 Validation

The validation is about the ontology definitions which should most real possible model and represents a defined domain [24], i.e., indicates if the ontology definitions are a model of the real world [39]. The validation is made by the next techniques:

- **Gold standard:** In this validation, the ontology is compared with a gold ontology that was created by an expert, where both represent the same domain; it assumes the gold ontology is completed and corrected else the validation could have many errors [17] and is commonly used for ontology which was created by semi-automatic and automatic process [40].

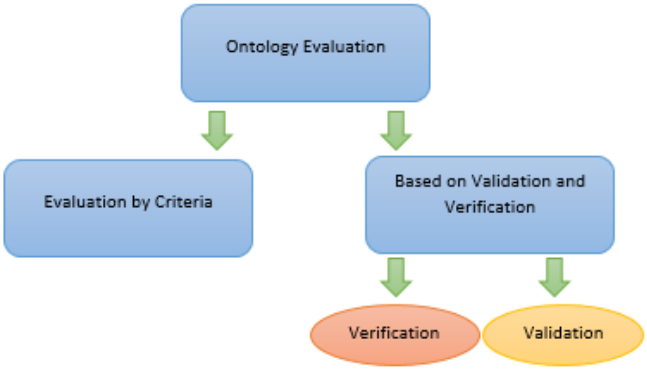

Fig. 2. Ontology Evaluation Approaches.

- **Application based:** the application based validation is a focus for determining if the results of the proposed ontology satisfy or not the task for which it was done [3].
- **Data driven:** for applying this validation is necessary to compare the information of the ontology with existing data about the same domain meanly using a corpus of text documents [3]. A very important aspect in this validation is determining if the ontology has enough elements for representing the domain [15].
- **User based:** basically, this validation is about the experience and perspective around the final user because it becomes suggestive and empiric; for minimizing the error it is advisable the user be an expert in the ontology domain [17].

3.3 Evaluation by Criteria

The evaluation by criteria is a focused technique in aspects or features which can be quantifiable [20] in order to ease the requirements analysis and some of them can be measured by ontology tool as reasoners [40]. In the Table 1 some criteria are described.

3.4 Ontology Evaluation Related Works

Wang et al. [38] developed an ontology using a geographic (spatial and temporal) knowledge of a gazetteer to associate natural hazards news reports by patterns; the main concepts are Happening for describing the processes that occur during

Table 1. Criteria for the ontology evaluation.

Criteria	Description
Lawfulness	About the syntactical error frequency [3]
Richness	Quantifies the most important syntactic features are used in the ontology [3]
Adaptability	How the ontology responses in future uses [20]
Clarity	To communicate about the meaning of the terms independently of the context [20]
Closeness Index	Measures the closeness or structural resemblance among the concepts [14]
Similarity Index	About the proposition correctness into knowledge structure [14]
Accuracy	Measures the representation of knowledge within the ontology in relation to the real world [37]
Coherence	Measure if exist contradictions among the elements of ontology according to logical consistency[37]
Computational Efficiency	Measures the reasoner performance when processing the ontology [15]
Conciseness	About the existence of irrelevant information unnecessary and redundancies [15]
Modularity	Indicates if the ontology was created with an appropriate methodology in order to define if exist reusable components [8]
Tangledness	Measures the distribution of multiple concepts and if exists intersections into the structure [40]
Connectivity	Indicates the most important concepts based on the amount of relationships. [40]
Consistency	Indicates if exists a contradiction among the definitions of the ontological elements [10]
Completeness	About if the content of the ontology is explicit or can be inferred in order to consider it complete [10]
Sensitiveness	Measures how a small change in a definition modifies other elements [10]
Standard Coverage	Identifies elements which are not defined in the ontology [21]
Coupling	About the number of external concepts that are referenced or imported [12]
Coverage	Indicates how well the ontology represents or models the domain [12]

hazard events and object to indicate the involved entities, and the relationships are is-a and part-of type.

In the evaluation ontology area, Ying Shen el at. [29] propose an ontology evaluation approach based on entropy by three elements: data amount, data quality and finally, ontology structure and text visualization, for this, the ontology was seen as a graph where the entropy is measured between two elements and if the value is high it indicates that there is a high redundancy. Another work about evaluation was presented by Djuana [7], he evaluates a folksonomy-based ontology by gold-standard using some important references into state of the art in order to validate the coverage for wider the ontological elements.

There are algorithmic methods for semantic validation of UML (Unified Modeling Language) class diagrams using an ontology as a reference in the domain; the ontology determines if the elements and relationships into diagram are contradictory or not and if are into domain [27].

Barchini et al. [2] propose four dimensions for ontology evaluation since ontology quality approach: descriptive, structural, functional and operative; descriptive dimension refers how well the ontology gives information about its features, structural dimension about how the ontology specifies its elements and definitions, functional dimension about the ontology capacity for giving functions in order to satisfy specific requisites and operational structure determines the ontology capacity for integrating to other physical and logical agents. The ontology proposed by Tovar [33] is a tool for the search information about the social service in a higher level education institution was manually created and validated by the answers of some competency questions.

There is a methodology for ontology evaluation in restricted domains by lexico-syntactic patterns, grouping by formal concept analysis, similarity, latent semantic and dependence graphs using corpora as a reference providing a score based on accuracy measure [36]. Further, the latent semantic analysis is defined as a technique that assumes the words in a common context are semantically related [34].

There are ontology evaluate focus as ontology definitions, the software used for building, share and reusing elements and the documentation about its [9] and some of them are focused to evaluate only ontological elements as semantic relations [35].

4 Ontology Applications Related Works

The representation of the information as the main purpose of an ontology that is why we can many applications about the use of information extraction techniques belonging to NLP (Natural Language Processing) as a tool for ontology designing, creation and instancing. For example, to store the clinical histories of patients, didactic sequence design based on competencies used by an upper middle education professor approach and the creation of management of heterogeneous data system in a university.

Kuna et al. [16] propose an ontology as an extension of an information retrieval system specifically in the query process, this work is designed for scientific document search in the computer sciences domain.

In the medical area, it has proposed to use an ontology for integrating information by heterogeneous way in order to create a repository using a similarity detection algorithm; for creating the mean ontology, it was necessary to mapping the known features to extend the domain [25]. Another application in the same area, it is the use of an ontology for enriching the diabetic patient education in a personalized way [23].

A case of use of an ontology is monitoring of a multi-agent system based on sensors; the ontology saves information about the system process and throws alerts when some sensor does not work on the different physical and logical components of the system [6].

5 Conclusions and Future Work

The ontology is an important standard for information representation, but also when is evaluated can infer knowledge in order to expand itself. We can say the ontology verification is made by measuring features and mathematical functions and the validation is guaranteed by knowledge previously given by an expert in the domain.

In the case of ontology evaluation by criteria, it can use the most appropriated criterion (or a set of them) according the kind of the ontology or its purpose. There is not an only strategy for ontology evaluation that guarantees the best performance, however the evaluation results will depend of a combining between the ontology purpose and the used strategy, in many cases.

Acknowledgement. This work is supported by the Sectoral Research Fund for Education with the CONACyT project CB-257357, and partially supported by the VIEP-BUAP.

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