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Application of ontology modularization to human-web interface design for knowledge sharing

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ABSTRACT

Ontology has received considerable attention in the semantic technology community. This paper discusses the roles of ontology modularization in human-web interface design for knowledge sharing. It stresses that ontology can support human-web interaction as a key component of knowledge sharing on the Internet. The paper proposes an approach of ontology modularization to navigating and searching web portals for the purposes of knowledge sharing. A case study of human-web interface design using ontology modularization for a commercial software web portal is used to illustrate the application of the proposed approach.

1. Introduction

Ontology is one of the important topics of the semantic web (Garrido & Requena, 2012; Kim, 2002; Otero-Cerdeira, Rodríguez-Martínez, & Gómez-Rodríguez, 2015). Ontology is a science that studies explicit formal specifications of the entities in the domain and the relationships between these entities (Gruber, 1993). An ontology is a specification of a conceptualization of the subject (Gruber, 1995). The concept of ontology is broad, and there have been many diversified ontology research streams. In the computing field, the research into ontology primarily focuses on information processing automation which is guided by the framework of the standard ontology modeling language (OWL, 2015). In this direction, ontology is an extension of XML style tools to support computer search engines. In the data mining field, an ontology is an abstraction from a set of massive textual data on the web (Ding & Foo, 2002; Rios-Alvarado, Lopez-Arevalo, & Sosa-Sosa, 2013). Another view of ontology research affirms that the major objective for people to develop and use ontologies is knowledge sharing in a certain community (Lanzenberger, Sampson, Rester, Naudet, & Latour, 2008; Yoo & No, 2014), and ontologies are user-driven rather than innate (Liu, Zheng, Tang, & Chen, 2014; Wang & Wang, 2008). Hence, ontology can be a purposeful knowledge modeling tool and shall play a directing role in human-computer interaction for knowledge sharing.

Research into user interface with ontology visualization has been investigated in the ontology engineering field, and new ontology visualization approaches are imperatively needed to assist various application areas to pursue diverse goals and requirements (Ivanova, Patrick Lambrix, Lohmann, & Pesquita, 2015). In fact, there is a lack of research into the use of ontology to visualize web contents for web navigation. This lack of integration of ontology and web navigation neglects the relationship between the semantic web and the world wide web.

This paper discusses the properties of ontology for human-web interaction in general, proposes an ontology modularization model and describes an ontology visualization approach to the navigating and the searching of web portals in the context of human-web interaction for knowledge sharing. Specifically, this study proposes an ontological semantic network model as the base of the human-web interfaces for web portals and defines ontology modularization operations to implement the presentations of the networked ontologies for the human-web interactions in navigating the web portals. The rest of the paper is organized as follows: Section 2 provides a literature review of related work that raises arguments that lead to the research question of ontology for human-web interface design. Section 3 proposes the ontology modularization model for knowledge sharing on the web. Section 4 presents a case study to support the proposed model. Finally, Section 5 concludes the study.

2. Literature review of related work

2.1. Ontology in web knowledge sharing

Web portals have been widely used to disseminate information and knowledge sharing. There have been many definitions of knowledge used in various disciplines (Lasierra, Roldán, Alesanco, & García, 2014; Liebowitz, 1999). We follow Zeleny's (2000) definition: knowledge is purposeful coordination of human actions. By this definition,

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individuals construct their own knowledge through experiencing and interacting with the web for actions. A challenging issue of knowledge sharing on the web is the disengagement of the posters and the users due to a lack of effective design approach to the organization of web portals. To make a web portal more useful for knowledge sharing, an interactive layer between the users and the web portal must be developed to facilitate knowledge sharing. This middleware layer supports the dynamic organization of the web portal for active knowledge sharing.

Ontology represents the concepts and the relationships between these concepts (Gruber, 1993). Ontology has been a tool of knowledge sharing (Lasierra et al. 2014; Yoo & No, 2014), and ontologies are considered one of the pillars of the semantic web (Ehirg, 2006). However, the commonly applied ontology models in the literature do not present the semantic relationships between the concepts explicitly; but, rely on companion algorithms to generate semantics. For example, countless research papers in the literature have used Protégé (2015) to edit their ontologies with no explicit semantics other than the simple lines between the concepts because the diagramming tool does not have an element for complicated semantics other than the hierarchical relationships between the concepts. The pitfall of the lack of semantic elements in ontology construction and ontological information processing causes the absence of ontology in human-web interaction for knowledge sharing. Accordingly, investigations of how ontology can coordinate operations, learning, and decision making through human-computer interaction to support the user's actions are critical for knowledge sharing on the web.

2.2. Ontology presents the object-oriented vision of knowledge resources

According to the Resource Description Framework (RDF) (W3C, 2015), a primitive ontology is a triple containing a subject, an object, and a predicate (relationship), or simply representing the reciprocal relationship of resource objects (dual subject and object). In this study, a static web page in the web portal is a resource object and can be represented as an entity by the ontology of the web portal. Rationally, a web portal can be represented by an object-oriented model that represents the relationships between the web portal resource objects (artifacts). The premise of object-oriented modeling is that objects are grouped into categories or classes for the application domain (Booch, Rumbaugh, & Jacobson, 2005). Categories are organized into hierarchies in which the sub-categories inherit properties from their super-categories. A sub-category can inherit from multiple super-categories. Inheritance relationships result in static connections between the web portal objects. In addition to inheritance relationships, the object-oriented paradigm applies so called message sending from one category to another to make dynamic connections between the categories. In the context of ontology, static relationships between the entities represent the hierarchical structure of the ontology, and dynamic relationships between the entities represent the complicated network structure of the ontology. Specifically for web portals, the dynamic relationships between the resource objects accentuate the contingent access paths to the web sites.

The ontological approach is a powerful modeling approach; however, without a domain analysis for particular types of applications, the ontological approach remains a virtual philosophy rather than a concrete technique for objects sharing. To build an ontology based on the methodology progression, the ontology of a web portal must present the object-oriented vision. The task of a domain analysis for the construction of an ontology is to define the categories of web portal resource objects and their semantic relationships, as illustrated later in the case study of this paper.

2.3. Ontological representation of knowledge schemata

While the Internet makes organizations easier to acquire, generate, and store information, the transition from information to human's knowledge is a major task of knowledge sharing to optimize the utility of information (Blumentritt & Johnston, 1999; Guarino, 1995). Web portals facilitate the transition from information to knowledge for the user, but the design of the human-web interface for the transition is a challenging task. Research (Green & Rosemann, 2004; Nilakanta, Miller, & Zhu, 2006; Welty, 2003) has confirmed that ontology can play key roles in the transition from information to human knowledge by aggregating and synthesizing the codified knowledge to support knowledge sharing. Ontologies have been with us for a quite long time. For instance, the ER (entity-relationship) chart is a general type of ontology for relational databases. In comparison with the ER charts for relational databases, ontologies for web portals are much more complicated due to the complex properties of the web portals and the diversified context of subjects for knowledge sharing. The ontological representation of a web portal is envisaged as the knowledge schemata that fit the applications related to the web portal. A web portal can have three different views: designer's view, posters' view, and users' view, and the integration of the three views of the organizational schemata can be represented by a common ontology that guides creating, editing, and sharing of the web resource objects. However, the literature shows little about how ontological representation of a web portal can serve as the interface between the users and the web portal to improve the usability.

2.4. Ontology visualization

Research into graphics in information systems has a relatively long history (Montazemi & Wang, 1988). Historically, research in this area has been focusing on the cognitive effects of graphics on the human reaction to an information environment. Time saving in actions, precision of the perceived data, and ease for recalling are common concerns of the use of business graphics (DeSanctis, 1984). Later, static cognitive maps were promoted as management tools (Fiol & Huff, 1992). The concept of graphical representation of knowledge structures has been developed a long time ago (e.g., Quillian, 1968). A simple form of graphical representation of knowledge schemata is box-linkages graphics that represent objects and relationships between the objects (Wang & Ariguzo, 2004). Recently, there have been many graphical ontology editors available on the Internet (Katifori, Halatsis, Lepouras, Vassilakis, & Giannopoulou, 2007; Ramakrishnan & Vijayan, 2014). While existing ontology editors can have sophisticated graphical or analytical functions for a particular domain, they are not significantly different from ordinary graphics drawing tools in terms of graphical presentation. The question of how to use visualized ontology as a human-web interface for the user to effectively navigate and search web portals for knowledge sharing remains unanswered in the literature. As discussed in the next section, ontology modularization can be integrated with ontology visualization for human-web interface design to enhance the user's cognitive process in searching web information.

2.5. Ontology modularization

According to Beckman (1999) and the references in his article, including Alter (1996), Tobin (1996), and van der Spek and Spijkervet (2005), knowledge representations include data of facts, information of summarized data and cases, knowledge representations for procedures, rules, ideas that guide actions and decisions. In an ontology supported web portal environment, all these resource objects can be semantically linked into a network. In this study, ontological representations foresee a network model instead of a hierarchical model