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A REVIEW OF TECHNIQUES FOR ONTOLOGY EDITOR EVALUATION

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ABSTRACT

This paper presents a survey on existing work on usability evaluation of ontology editors. It also highlights the lack of a standard approach for quantitative evaluation of ontology editors. An ontology editor facilitates the developers in ontology creation. It provides a GUI abstraction over common ontology development tasks and hides the technical complexities from the users. Different ontology editors have evolved in the last few years. Despite the continuous evolution of these tools, there has not been enough work done on usability evaluation of these tools. It is observed that most of the proposals evaluated their advocated tool by performing a feature-wise comparison with other tools. Only a few works quantitatively evaluate their proposed ontology editor with well-known ontology editors. This paper compiles existing work on usability evaluation of ontology editors. Based on our study, various issues involved in development of a standard approach to ontology editor evaluation have been highlighted. The paper concludes with recommendations for a standard approach to usability evaluation of ontology editors.

Key Words: Ontology Editor, GUI Evaluation, Usability Evaluation, Quantitative Evaluation, Standard Approach to Evaluation

INSPEC Classification : A9555L, A9630, B5270

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1. INTRODUCTION

Semantic web provides a framework to promote information sharing and integration of web contents beyond organizational boundaries. The W3C semantic web stack recommends different techniques, tools and methods for realization of semantic web. Ontology is one of the most important constituents of semantic web. Ontology provides a shared vocabulary for a domain by describing the concepts used in a domain, attributes, relations and axioms etc. These details are normally specified in an ontology language for further processing by computers. Different ontology languages have been proposed in literature. Simple HTML Ontology Extension (SHOE), Resource Description Framework (RDF), DARPA Agent Markup Language (DAML) and Web Ontology Language (OWL) are examples of some of the ontology languages [1].

Since, ontology languages are designed for processing by computers, they are not comprehensible for common users. The development of ontology becomes very difficult if an ontology developer has to write ontology in a formal language. To ease this task, different ontology editors have evolved. An ontology editor provides a graphical user interface (GUI) abstraction over various operations involved in ontology creation. A user can create a class and its sub-classes; add properties and relationships; create instances; and specify rules etc. The generated ontology can then be exported into different ontology languages (SHOE, RDF, DAML and OWL etc.) without letting the user to worry about the intricate details of ontology languages. An ontology editor also provides various additional features. A user can visualize ontology from different perspectives, reason on these ontologies and check the ontology for consistency issues etc. In addition, some ontology editor provides a methodological approach to ontology creation [2][3].

There has been continuous evolution of ontology editors since last few years. Among them, Ontolinua, Protégé, WebODE and SWOOP etc. are some of the popular ontology editors [3]. These editors have been proposed realizing the absence of certain features in other available editors. For example, some editors were proposed to address scalability concerns, while others were evolved to enable distributed creation of ontology's. Most of the research proposals adopt their own techniques and criteria for evaluation of their advocated editors. These proposals qualitatively evaluated the ontology editors based on certain features. Only few works performed quantitative evaluation of ontology editors. These approaches make different assumptions about the experience, skills and knowledge of users who will be using ontology editors. They employed different design and instruments to gauge the usability of their proposed ontology editor. However, it becomes indispensable to evaluate usability of ontology editors from a standard perspective [4].

There has not been much work done on usability evaluation of ontology editors. To be precise, we don't find a single survey reported on usability evaluation techniques of ontology editor. Hence, this paper presents a survey of different works done on evaluation of ontology editors. Rest of the sections of this paper is organized as follows. The paper starts with a brief background study of the topic. The usability evaluation techniques for ontology developers are presented afterwards. In the last part of this paper, various recommendations based on the study are provided.

2. BACKGROUND AND RELATED WORK

Usability evaluation is not a new topic. Ample volume of research has been reported on usability evaluation of common graphical user interfaces i.e. desktop applications, website and mobile apps etc. This section starts with a brief discussion on common technique for evaluation of graphical user interfaces. There are some research works that have compared different ontology editors based on their features. This section also discusses those techniques [5].

2.1 Usability evaluation techniques

Usability of a system can be defined as the ease of use and learn ability of its interface. There are various approaches for usability evaluation proposed in literature. Figure 1 provides a summary of these techniques. These techniques can be broadly classified as usability testing, usability inspection and inquiry methods(UH)[5].

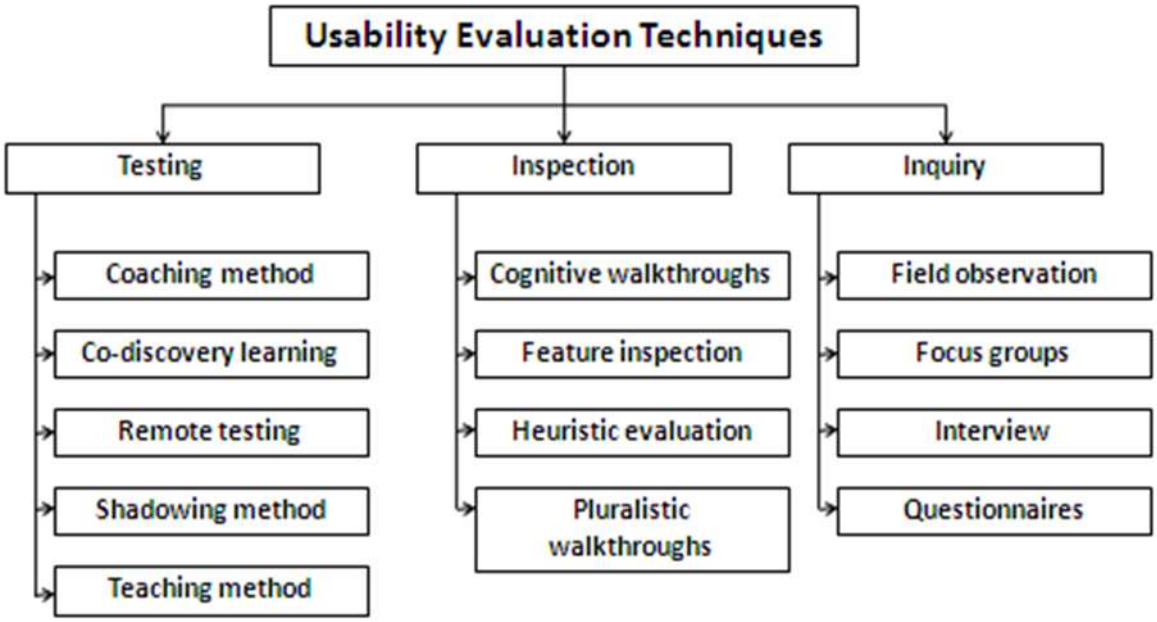

Figure 1: Summary of usability evaluation technique

The usability testing is performed by the users of a product to identify any serious problems in a user interface. For example, one of the usability testing techniques is coaching method that comprises a set of representative users and an expert called coach. These users ask the expert about different system related questions to identify usability problems. Another example of usability testing is co-discovery method, where two test users are asked to perform a task on using the gui [6]. The two users help each other to perform this task. Remote usability testing can also be performed when the testers and participants are at different locations. In shadowing method, the expert sits next to the tester to explain the test user's behavior. Finally, in teaching method, the test user first familiarizes itself with the system and then educates a novice user about the working of system [8][9].

As compared to usability testing, the usability inspection is generally performed by experts, and sometimes by developers. The experts involved in inspection can be human factor engineers, software developers or marketing people etc. The objective is to find usability issues in the interface design. An example of usability inspection is cognitive walkthroughs, where the experts inspect the usability of an interface by walking through different tasks of the system. In pluralistic walkthrough, a group of people step through different tasks together to find potential usability problems. Another technique is feature inspection, in which the evaluators investigate the different features of system for possible usability issues. Similarly, in the heuristic evaluation, a set of usability heuristics like visibility of system, consistency, exception handling strategy and documentation etc. are used to guide the usability evaluation process[10][11].

The final approach of usability evaluation is inquiry method, in which the evaluators get feedback about user interface by observing users interaction and getting feedback directly or via written information. For example, evaluators can observe the behaviors of users at their work places called field observation; identify usability problems via moderated group discussions i.e. focus groups, can conduct interviews with users or can ask the users to submit feedback through questionnaires[12].

2.2 Qualitative Evaluation of Ontology Editors

There have been several studies conducted on qualitative evaluation of ontology editors based on various features provide by these tools. Table 1 summarizes these research efforts.

Kapoor and Sharma performed a comparison of ontology editing tools on the basis of four types of parameters i.e. tool's architecture, interoperability, inferencing services and usability [13]. Mizoguchi evaluated different ontology development tools based on criteria like development process management, collaboration, theory awareness, architecture, interoperability, ontology model, instance definition and inference etc. [13]. Norta et al. did a comparison of various ontology development tools based on functional and non-functional requirements for a good ontology editor (Norta, Carlson et al. 2010). Among the functional requirements are collaboration, multilingual and natural language support and verification etc. Among the non-functional requirements are features like modifiability, inerrability and portability etc. The utility of an editor is computed by a formula aggregating the requirements score. Islam et al. also provides a comparison of different ontology development tools based on their availability, architecture, imports/exports and supporting tools etc [14][15].

Name	Basic idea / motivation	Parameters	Tools compared	Any framework / consolidation approach
(Kapoor and Sharma 2010)	To evaluate tools based on interoperability, openness, easiness to update and maintain, market status and penetration	Extensibility, storage, import/ export, merging, inference engine, exception handling, consistency checking, collaboration, library, visualization, versioning	Apollo, Protégé 3.4, IsaViz, SWOOP	No
(Mizoguchi 2003)	Focus on dynamic aspects of ontology development	Methodological support, collaboration, theory awareness, architecture, interoperability, ontology/model instance, instance definition, inference,	OntoEdit, Hozo, WebODE, Protégé,	No
(Norta, Carlson et al. 2010)	Comparison is done in context of electronic B2B-collaboration	Functional requirements Collaboration, development in different human languages, multi-ontology support, verification, visual abstraction, natural language support, automated information extraction. Non-functional requirements modifiability, inerrability, portability, interoperability performance, security, usability, flexibility, feasibility, scalability, applicability, completeness etc.	NeOn, Protégé, CmapTools, TopBraid composer, HOZO, OntoBroker	Yes
(Islam, Abbasi et al. 2010)	Comparison of ontology editing tools in context of semantic web	Extensibility, collaboration, architecture, import/export languages, supporting tools etc.	Protégé, OntoEdit (Free), DOE, IsaViz, Ontolingua, Altova SemanticWorks, OilEd, WebODE, pOWL, SWOOP, TopBraid Composer,NeOn Toolkit, Morla, OBO-Edit, Hozo, OntoBuilder, WSMO Studio	No

Table 1: Summary of qualitative approaches to ontology editor evaluation

3. USABILITY EVALUATION OF ONTOLOGY EDITORS

The research on usability evaluation of ontology editors can be described in two major categories. There are some studies done on comparison of selected ontology editors. In addition, there are proposals that have used usability evaluation techniques for evaluation of advocated editing tool. In the sections below, we will discuss these two techniques. We also discuss briefly, some usability studies done on tools related to ontology editing.

3.1 Studies on usability evaluation of ontology editors

Following are some of the usability studies reported for comparison of ontology editors:

3.1.1 Duineveld et al. (2000)

The earliest work on evaluation of ontology development tools is reported by Duineveld et.al [4]. A framework for evaluation has been proposed which evaluates the tools on three dimensions. The general dimension investigates the tool for features that are also found in other programs. The ontology dimension analyzes the tool for features specific for ontology development. The third dimension cooperation evaluates the tool for features required to support collaborative ontology development. A checklist of questions pertaining to each dimensions were use to evaluate five tools i.e. WinProtege, Ontolingua, WebOnto, OntoSaurus and ODE. Based on the checklist, a qualitative comparison of different features of the tools was performed.

3.1.2 McPherson (2010)

McPherson 2010 evaluated usability of Protégé and OntoWiki. To evaluate the tools, a questionnaire was created. There were 16 participants of various age groups from different domains such as computer science, biology and mathematics. The participants were requested to complete various tasks in a closed environment and rate their experience. The comparison was performed based on parameter such as reliability, simplicity and learnability of tool [5].

3.1.3 Alatrish (2013)

Alatrish performed a comparison of five ontology editors Apollo, Onto Edit, Protégé, Swoop and TopBraid Composer [1]. The evaluation comprises qualitative evaluation of tools based on features such as architecture, interoperability, knowledge representation, inference support and usability of tools. The usability of the tool is performed based on support for creating taxonomies of concepts, relations, clipping of views, zooming, collaboration and support for libraries.

3.1.4 García-Barriocana et al. (2007)

García-Barriocana et al. used a hybrid approach to usability evaluation by combining techniques of usability testing and heuristic evaluation [7]. Three groups of evaluators from different backgrounds were formed. The process comprises pre-selection, evaluation, and a de-briefing and severity-rating phase. In the pre-selection phase, some tools were discarded considering different aspects of tools. During the second phase, heuristic evaluation of tools is performed. In the final phase, the evaluators were asked to fill a

questionnaire, reporting their overall satisfaction.

3.1.5 Khondoker et al. (2011)

Khondoker et al. performed an online survey in which users were asked to fill a questionnaire [9]. The questionnaire comprises questions about four usability components i.e. tools, task, environment and user. The participants included beginners as well as experience ontology developers.

4. ONTOLOGY EDITOR PROPOSALS BASED ON USABILITY EVALUATION OF PROPOSED TOOL

Following are some of the studies that have used usability evaluation for validation of their proposed tool.

4.1 Tudorache et al. (2010)

Tudorache et al. presented ICD Collaborative Authoring Tool (iCAT) as a customization of WebProtege (Tudorache, Falconer et al. 2010). The tool provides various additional features such as discussion threads, tracking of changes and content reviewing etc. The tool was evaluated by eleven managing editors who were domain experts i.e. knowledge of medial domain. During the evaluation, the participants were briefed about the tool first through demonstrations as well as presentations. The participants were then asked to explore the tool and create ontologies while working in pairs. The participants were observed and asked few questions. After the evaluations, participants were asked to fill a questionnaire.

4.2 Bernstein et al. (2006)

Bernstein et al. proposed an ontology editor called GINO i.e. guided input natural language ontology editor. They evaluated the usability of proposed tool, six participants with no experience in semantic web and ontologies. The participants were initially introduced to the concepts and then asked to create ontologies. Using a key logger, various observations were about the evaluation session. For example, common mistakes by users, frequency of usage of backspace key, incorrect data entries made by user were recorded. Based on the information, a usability score was computed. At the end of session, participants were asked few questions to get feedback about the usability of tool.

4.3 Fortuna et al. (2007)

OntoGen, an ontology editor was presented by Fortuna et al. [3].For the usability evaluation of tool, a study was performed between two groups of users. First group had good knowledge of computer science, while the second group more knowledge about cognitive processes. The evaluation session lasted for 90 minutes and comprises three phases. The first phase introduces the reader about the purpose of tasks. In the second phase, users were first asked to fill an initial questionnaire. The participants were asked to test the system and then create sample ontology's. A questionnaire was then filled in the end by participants to provide their experiences about the system. In the conclusion phase, an informal discussion was done to discuss any final thoughts

or questions aroused during usability evaluation session.

5. USABILITY EVALUATION OF OTHER ONTOLOGY TOOLS

We close this section with a brief discussion on usability evaluation work on tools related to ontology development. Fu et al. performed usability evaluation of ontology visualization tools. A total of 36 participants from various domains such as computer science, biomedical, biochemistry performed the evaluation. The participants were asked to interact with the visualization tool in one-one session. The participants were first asked requested to complete a video tutorial and then start evaluation. The results were quantified using parameters of effectiveness, efficiency, workload and satisfaction. Funk et al. presented a controlled language for ontology editing and implementation software based on NLP tools. The usability evaluation process comprised of pre-test questionnaire, reading a manual, carrying out two ontology development tasks and filling out a post-test questionnaire. The pre-test questionnaire asked participants about their previous knowledge of ontologies and controlled language. The post-test questionnaire comprised questions to measure the usability score of tool. There were 15 evaluators having different level of expertise and experience.

Garcia et al. performed usability evaluation of OWL-VisMod, a visual modeling tool for OWL ontology's. The evaluation process comprised of 26 questions categorized into 22 closed ended and 4 open ended questions. Users were asked to download the tool and then answer questions about the effectiveness of the tool i.e. whether the visualization achieve the desired objective in opinion of user.

6. RESULT & DISCUSSIONS

Table .2 summarizes the research done on usability evaluation of ontology editors. Despite the intense need for evaluation of usability of ontology editors, the research on this topic is still at infancy stage. Only few studies have been reported on comparison of a set of selected tools for usability evaluation. Most of the proposals on ontology editing have performed a feature-wise comparison of their proposed tools. Recently, some ontology editors have emerged that have analyzed their proposals from usability perspectives. However, as evident from Table 2, these studies have adopted different approaches for usability evaluations. This paper recommends that there is a need for some standard approach to perform usability evaluation such that usability of all the tools can be measured on a common scale. However, the emergence of this standard requires deliberation on various key points.

The first key question is that 'should the evaluation performed be qualitative or quantitative in nature?' For qualitative evaluation, what are the key features of editors that should be analyzed? An important question is about the number of participants and level of each participant involved in evaluation. The participants can be novice with no knowledge of ontology and even they may not have any knowledge of computer science. What should be the mode of evaluation i.e. coaching, walkthrough or reviews. The next question is about the various stages for evaluation of tool. Is there any need for briefing the participants about the tool? Can the participants be provided manuals or documentation of ontology editor? What are the various tasks to be performed during

Name	Summary	Tools compared	Pre-session briefing	Post-session questionnaire	Usability evaluation procedure	Participants ontology development experience	Usability quantification
McPherson (2014)	To evaluate usability of ontology editors and determine the difficulties in adoption of ontology's	Protégé and Semantic Wiki	No	No	Perform various task and rate based on questionnaire	No	No
Duineveld et al. (2010)	To evaluate a tool from different dimensions i.e. general user interface, ontology support and cooperation	Ontolingua, WebOnto, ProtégéWin, OntoSaurus, ODE, KADS22	N/A	Yes	Evaluate tools based on different dimensions	Yes	No
García-Barriocana et al. (2005)	Evaluation of ontology editor based on heuristic assessment and user testing	Protégé 2000, OntoEdit, OILEd, KSL Ontology Editor, WebOde , WebOnto, KADS22	Yes	Yes	Create a small ontology, load a large ontology, search a class and property, perform annotation, update classes and properties	Nil	No
Khondoker et al. (2010)	Using online survey, obtain feedback of users	Protégé, SWOOP, Top Braid Composer, Internet Business Logic, Onto Track, IHMC Cmap Ontology editor	No	Yes	Get feedback from users based on their experience of using tools	Yes	No
Tudorache et al. (2010)	To evaluate the usability of a proposed ontology editor	iCAD	Yes	No	Exploration of tool	No	No
Bernstein et al. (2006)	To evaluate an ontology editor GINO, a natural language ontology editor	GINO	Yes	Yes	Create class Create sub-class Add data and object property Add instance and values Change the	Nil	Yes, Based On Sus (Brooke 1996)

					value		
Fortuna et al. (2007)	Integrates machine learning and text mining algorithms in user interface	OntoGen	Yes	Yes	Create an ontology and create two ontologies based on created ontologies	Minimal	No

Table 2: An overview of work done on usability evaluation of ontology editor

evaluation? What are the various parameters to be evaluated during evaluation (such as time to perform a task, errors made while performing a task)? Another important point to be considered is the need for a questionnaire to be filled after evaluation. This questionnaire can ask about user's experience of performing various tasks on the ontology editor. What should be the set of standard questions to be asked to the participants?

Based on the above questions, a standard for evaluation of ontology editor can be devised. The standard should consider the issues highlighted above such as a set of common steps, questions / checklists/ heuristics, and a standard formula to quantify the usability evaluation. Based on the evaluation score, various ontology editors can be compared.

CONCLUSION & FUTURE WORK

In this paper, an overview of various approaches to ontology editor evaluation has been presented. Based on the study, it is observed that there doesn't exist any standard approach to ontology editor evaluation. A small amount of studies have tried to evaluate usability of their proposed tool based on their own strategy. The paper highlighted various issues involved in the development of a standard approach to ontology editor evaluation. Based on these highlighted issues, a novel framework can be devised that evaluates various tools and provides a benchmark for comparison of various ontology editors from standard perspective.

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