ONTOLOGY EVALUATION APPROACH FOR SEMANTIC WEB DOCUMENTS

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DEDICATION

For Mama and Abah.
For dear siblings, grandmothers and grandfathers, families and friends.
In loving memory of late Grandmother-Atok Yam.
Thank you for the everlasting loves.
And thank you for the never ending support and prayer.
May Allah repay your deeds with happiness and peaceful in life and here-after. You, for repeatedly asking for my thesis, thank you for the years and for your secret prayers. May Allah ease us and our loved-ones.
This journey has made me believe that…

Along with Hardship, there is Ease (Al-Inshirah,94:5-6)

God will give what you need despite for what you want. And He is the best planner. And it truly is. =)

Nurhamizah Mohd Hamka
25 Ramadhan 1436

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ABSTRACT

Ontology is a conceptual tool used for managing and capturing information related to domain knowledge, such as the travel, education and medical domains. Publicly available ontology repositories like Falcons and SWOOGLE enhance the growth of ontology on the Web by providing a medium for ontology developers to publish their ontologies. In order to promote ontology reuse, a suitable approach for ontology evaluation is required that deals with ontology coverage for domain representation which includes an approach for validating the ontology with a corpus of information containing terms related to domain knowledge. Since contributions in ontology evaluation were introduced in different aspects, it is important to conceptualise related information to build an evaluation approach that can help users to select ontology. This work proposed OntoUji, an ontology that conceptualises information related to ontology evaluation. From OntoUji conceptualisation, these works proceed with the development of evaluation steps that are then converted into ontology evaluation algorithms to evaluate ontology documents retrieved from selected repositories according to data-driven evaluation approach. The data-driven approach focuses on evaluating the coverage of ontology using a set of keywords provided, yet similarly involves a comparison of ontological vocabulary with a pre-defined corpus, WordNet, gained from the information retrieval approach. The evaluation is then processed using Letters Pair Similarity algorithm as the selected similarity measures technique to process the ontology coverage result. The findings showed that the OntoUji ontology conceptualization helps to define ontology evaluation steps to gain similarity result for ontology selection.

ABSTRAK

Ontologi adalah suatu alat konseptual yang digunakan bagi mengurus dan menawan maklumat mengikut domain pengetahuan seperti domain pelancongan, pendidikan dan perubatan. Repositori ontologi awam seperti Falcons dan SWOOGLE meningkatkan pertumbuhan ontologi ke dalam Web dengan menyediakan wadah kepada pembangun ontologi untuk menerbitkan ontologi mereka sendiri. Untuk mempromosikan penggunaan semula ontologi, pendekatan ontologi yang sesuai amat diperlukan berkaitan dengan liputan ontologi bagi perwakilan domain termasuklah pendekatan untuk mengesahkan ontologi dengan korpus maklumat yang mengandungi istilah-istilah berkaitan pengetahuan domain. Memandangkan sumbangan dalam penilaian ontologi diperkenalkan dalam aspek yang berlainan, penting bagi mengkonsepsikan maklumat berkaitan pendekatan penilaian yang dapat membantu pengguna memilih ontologi. Kajian ini mencadangkan pembangunan OntoUji, iaitu ontologi yang mengkonsepsikan maklumat berkenaan penilaian ontologi. Berdasarkan konsep OntoUji, kajian ini membangunkan langkah-langkah penilaian yang kemudiannya ditukar kepada algoritma penilaian bagi menilai dokumen ontologi yang diambil dari repositori terpilih menurut pendekatan penilaian berasaskan data. Kaedah berasaskan data memberi fokus kepada penilaian liputan ontologi menggunakan satu set kata kunci yang diberikan, tetapi juga melibatkan perbandingan kosa kata ontologi dengan korpus yang telah ditentukan iaitu *WordNet,* yang diperolehi daripada pendekatan mendapatkan semula maklumat. Penilaian seterusnya dijalankan dengan menggunakan algoritma *Letters Pair Similarity* yang dipilih sebagai teknik mengukur persamaan bagi memproses liputan ontologi. Keputusan menunjukkan pengkosepan ontologi OntoUji dapat membantu dalam menterjemah langkah-langkah bagi menilai ontologi untuk memperoleh keputusan persamaan ontologi bagi pemilihan ontologi.

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LIST OF ABBREVIATIONS

API	*Application Program Interface*
CMS	*Content Management System*
FN	*False Negative*
FP	*False Positive*
HTML	*HyperText Markup Language*
IDF	*Inverse Document Frequency*
IR	*information retrieval*
LPS	*Letters Pair Similarity*
ORSD	*Ontology Requirement Specification Document*
OWL	*Ontology Web Language*
OWL-S	*Ontology Web Language–Semantic*
POS	*Part-of-Speech*
RDF	*Resource Description Framework*
RDFa	*Resource Description Framework in Attributes*
ROMEO	*Requirements-oriented Methodology for Evaluating Ontologies.*
SE	*Software Engineering*
TF	*Term Frequency*
TN	*True Negative*
TOVE	*Toronto Virtual Enterprise*
TP	*True Positive*
URI	*Uniform Resource Identifier*
URL	*Uniform Resource Locator*
WSDL	*Web Services Description Language*
WSMO	*Web Services Modelling Ontology*
XML	*Extensible Markup Language*

CHAPTER 1

INTRODUCTION

1.1 Overview

The Semantic Web is known for supporting the interoperation between computers and people. It is an enhancement of previous Web technologies that gives meaning to data in order to be exchanged by both parties (Berners-lee *et al.*, 2001). The Semantic Web, which is known as the "Web of data" (Berners-lee *et al.*, 2001), has the ability to support synchronisation of various information in terms of structure and usage, stored in a Web environment with the ability to manipulate the information.

The technology transformed within the Semantic Web is known as ontology, one of the backbones of the knowledge structure method. Ontology is "the backbone for Semantic Web" (Ding, 2010), where it helps to conceptualise information and gives meaning in order to enhance the reliability of information selection for the user. The term *ontology* was borrowed from the philosophical world by Gruber (1993) as "a specification of a conceptualization". This means that ontology is used to generate *lingua franca* of information specific domain knowledge or a hybrid of various types of knowledge in single-ontology structured documents. Some of the knowledge captured is then visualised into set of relationships between concepts,

individuals, or properties to describe the focused domain knowledge in triples. Ontology has been used tremendously in various fields like the biomedical area to conceptualise large amounts of medical information and keep it standardised (Bright *et al.*, 2012; Zeshan and Mohamad, 2012). Ontologies can also be implemented in other generally related systems, such as tourism (Yu *et al.*, 2005). It shows that ontologies have been widely used in different bodies of knowledge for the representation of data.

The validation of an ontology is one of the important tasks during the development or selection of an ontology (Corcho *et al.*, 2003); in fact, the process of ontology evaluation is done simultaneously within the development of the ontology until the release phase for public use. The existing work gathered the different methods for evaluation, which depend on ontology types, the domain knowledge it represents, and the methodology used for evaluation. Some of the existing works include gold-based evaluations that aim to gain direct feedback for ontology concept representation from experts within the body of knowledge, while some validation approaches contribute to analysing the content or structure of the ontology documents, depending on reliable documents (Sabou *et al.*, 2006).

Building domain ontologies from scratch is cumbersome; reusing existing ontologies is easier. Since large numbers of ontologies are available online, this indeed values the process of validation. Whether by automatic or semi-automatic validation, the measure helps to indicate the suitability of an ontology document to be used by users in a variety of usage objectives. By helping users with the selection of the ontology to be used for their own usage, this helps increase the usage of publicly available ontologies (Kalfoglou and Hu, 2006).

1.2 Motivation

Ontologies have increasingly been published online. As a part of the Semantic Web technology that enables users to increase the interoperation between information on the Web, the backbone of information linking is within the ontology Uniform Resource Identifier (URI). In addition, users are faced with a number of ontology repositories that contain a large number of ontology documents. The search for ontologies using keywords within the repositories returns a number of ontologies in the results, which involves a certain degree of coverage measurement of the ontology. The description of the ontology coverage is not displayed within the ontology results, which makes it difficult for the users to select a suitable ontology for their own purposes.

The selection of ontology is based upon the criteria and domain knowledge required from the adopter of the ontology, the user. Ontologies have diverse objectives in terms of use, whether as reference for domain knowledge or a standard of information required for the software development life cycle for traceability requirement support (Ruiz and Hilera, 2006). Different criteria of evaluation are related to the types of measurements that could signify the criteria. Although related works on ontology evaluation have cited the difficulty to attach suitable measures to surpass ontology evaluation criteria (Vrandečić, 2009), the identification of ontological aspects could also help in identifying suitable measures.

Public access ontology repositories encourage users to access ontology selections by providing general keywords, as only users know their own types of desired ontologies. The known public access ontology repositories are SWOOGLE, Falcons, and Watson. There are several known repository lists in the review by d'Aquin and Noy (2012). Noy *et al.* (2005) stated that users determined most of the ontology rankings by popularity of use, but there is an issue on the credibility of users that rank the attached ontology documents. Ontology search engines like SWOOGLE rank ontologies using the PageRank algorithm (Roger, 2002), but the search results do not state the description of the ontology documents, and the

availability of the ontologies is questionable. Some return unavailable ontologies (Farrag *et al.*, 2013).

It is known that building ontologies from scratch is considered a large effort (Kayed *et al.*, 2008), hence reusing existing ontologies is more appealing. However, selecting a suitable ontology requires proper evaluation methods. In terms of keyword search ontology methods, the relevant approach in this process leads to the data-driven approach of evaluation. In addition, content-based evaluations (Jones and Alani, 2006) work as indicators of the coverage of ontology documents for a specific body of knowledge. It requires the ontology content to include relevant keywords that represent the domain of the covered services.

1.3 Problem Statement

The search for ontologies from the Web requires the users to provide relevant keywords that might match the vocabulary of the ontology, whether on concept matching or instance matching. Users could have a problem selecting a suitable ontology because of the large numbers of ontologies published in the search results (Fahad and Qadir, 2008; Noy *et al.*, 2013; Tartir *et al.*, 2005). The limitations of viewing the ontology description make it difficult for the user to select the ontology. The description of the ontology can be included during the development of the ontology by inserting <Description> tags with information that can be manipulated for viewing in the ontology repositories. Yet, some ontologies do not include description tags.

Apart from the vast numbers of available ontologies, the issue faced by most users is the suitability of the ontology to fit their requirements (Fahad and Qadir, 2008; Gangemi *et al.*, 2005; Gómez-pérez, 2001; Oh and Yeom, 2012; Sabou, 2006; Staab *et al.*, 2004; Tartir *et al.*, 2010). Moreover, ontologies aim to be reused. The necessary criteria must be identified first since the methods of evaluation depend on

the objectives of the selected criteria. As ontologies are used for numerous purposes, diverse kinds of evaluations are required (Gómez-Pérez, 2001).

Selection of ontologies from publicly available ontology repositories require parts of the ontology to match the keyword search input provided by the user. In addition, the relevancy of the ontology is also required as part of the selection process, as the ontology document must include relevant terms from the provided keywords. In order to select a suitable ontology that covers the domain knowledge required from the search process, the main research question of the above research gap is identified as:

"How to improve ontology evaluation based on coverage selections in the Semantic Web?"

1.4 Research Questions

The research study reviews the following research questions, which signify the above objectives of findings.

RQ1: What are the proposed evaluation approaches to evaluate ontologies in the Ontology Web Language (OWL) file format for a Semantic Web document?

RQ2: What are the components of highlighted information during the evaluation of an ontology for a Semantic Web document (Staab *et al.*, 2004)?

RQ3: What are the requirements and criteria objectives to be achieved regarding the evaluation of a domain ontology for a Semantic Web document?

RQ4: How to design an algorithm to evaluate domain ontologies based on the requirements and criteria objectives that are identified?

1.5 Objectives

The aim of this research is to propose an enhanced approach for the evaluation of domain ontology coverage for Semantic Web documents. The details of the objectives are as follows:

1. To propose ontology for evaluating ontologies in the OWL file format for Semantic Web documents.
2. To evaluate ontologies using steps to select ontology for Semantic Web documents.

1.6 Scope of Research

Ontology evaluation aims for coverage criteria to ensure that the selected ontology includes domain knowledge contained in the ontology documents; therefore, the similarity string algorithm and proper corpus reference documents are needed for measuring ontological document coverage in the selected domain for ease of ontology selection for Semantic Web documents. This research proposes to validate ontologies via vocabulary aspects by proposing a similarity algorithm. The aim is to measure the matching of ontology content with a list of terms from a corpus as frames of reference.

Coverage is the main criteria of measurement for ontology validation consisting of similarity measurements from a list of terms with triples within ontology documents. The ontology focused on the selection of ontology in the Semantic Web is on OWL based ontology language during the evaluation process to support Jena and the OWL plugin to read the ontology documents downloaded from the Web. The concept and literal extraction is done to process the matching measurements with the terms, and the result gained will be validated via precision

and recall for relative comparison. This study excludes the semantic similarity measures and only focuses on the corpus or data-driven based evaluation that consists of the vocabulary aspects of the ontology.

1.7 Thesis Structure

There are various approaches and methods that provide many inputs for ontology evaluation. This chapter states the objectives to accomplish enhanced evaluation ontology approaches. The structure of the thesis is a literature study of ontologies and the evaluation approaches of the ontologies in the Semantic Web in Chapter 2. Chapter 3 describes the methodology of research in this study, and Chapter 4 describes the first objectives of this work on components of information for ontology evaluation, which are described in the form of ontology conceptual methods.

Chapter 5 describes the algorithm used to evaluate the selected ontology based on similarity measurements. Here, Wordnet (Fellbaum, 1998), an English lexical library are used as a reference for the algorithm measurements to be compared with a list of ontologies for the evaluation process. Chapter 6 entails the validation of the proposed algorithm in Chapter 5 and discusses the findings gathered from the validation process using precision and recall. The final chapter concludes the research findings and provides suggestions of improvements in future works related to the coverage criteria of evaluation in the Semantic Web.

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