Semantic Web: A Context for Medical Knowledge Discovering and Sharing

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ABSTRACT

Introduction: This article will discuss Semantic Web standards and ontologies in two areas: (1) the research and (2) healthcare. Semantic Web standards are important in the medical sciences since much of the medical research that is available needs an avenue to be shared across disparate computer systems.

Material and Methods: This review article was performed based on a literature review and internet search through scientific databases such as PubMed, Scopus, and Web of science and Google Scholar.

Results: Ontologies can provide a basis for the searching of context-based medical research information so that it can be integrated and used as a foundation for future research. The healthcare industry will be examined specifically in its use of electronic health records (EHR), which need Semantic Web standards to be communicated across different EHR systems.

Conclusion: The increased use of EHRs across healthcare organizations will also require ontologies to support context-sensitive searching of information, as well as creating context-based rules for appointments, procedures, and tests so that the quality of healthcare is improved. Literature in these areas has been combined in this article to provide a general view of how Semantic Web standards and ontologies are used, and to give examples of applications in the areas of healthcare and the medical sciences.

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INTRODUCTION

Semantic Web (SW) was first proposed in 1989 by Tim Berners-Lee, the father of the Web. Lee foresaw the future of the web, which, unlike the current web, can be understood and processed not only by humans but also by machines. And explained the main purpose of the SW is to make it possible to work human and machine together [1- 4].

The concept of SW expresses the development and spread of the web in terms of creating meaning and context for information. In fact, SW is the universal space of intelligent machine computing, in which all knowledge bases will be put together in a meaningful way and with the ability to understand each other conceptually. And instead of producing information for machine, it will be produced for human consumptions. SW pioneers believe that SW creates a structure for meaningful content on web pages and is a key factor in maintaining quality on web. It also helps researchers identify quality websites for searching [1, 3, 5].

Since one of the main challenges in the field of medicine is the extraction of knowledge from the heterogeneous data and knowledge Sources, the SW can improve the quality of care by integrating data silos. Because decision making in the healthcare is often a collaborative process that requires information sharing, this function helps the clinicians to collect the right information and avoid repeating the experiences. By considering that a proper information sharing had to performed in three significant communication levels such as The syntax level (uncommon exchange format and syntactic operability), The semantic level (meaning),and pragmatic level (contextual information) [6].

Given that the SW increases the integration of multiple sources to obtain new and useful results, facilitating and exploiting information by connecting them to their definition and context, it can be concluded that using the SW can cover the above levels. To have the SW must be paid attention to two main aspects that are categorized in ontologies for consistent terminology and standards for interoperability. This article focuses on these two categories in detail.

ONTOLOGY

Ontology is the science of cognition and classification of concepts that are exist in different fields and generally rooted in the philosophy of science. Barry Smith- an ontology specialist in the field of biomedical- defines ontology as a branch of philosophy, the science of the types and structures of objects, their properties and their relationships in the real world. In other word, an ontology searches for the classification of entities. Each discipline can have its own preferred ontology by defining the vocabulary and rules of that discipline based on its theories" [7].

In SW, Lee introduces ontology as "a text or a file that defines the relationship between elements". An ontology introduces the concepts of a domain, the relationship between these concepts (IS-A), the vocabulary used to design them, and their formal and informal definitions. In the ontology, IS-A relationship plays a major role because it provides a tree structure for it. An ontology structure should not necessarily be a tree.

Because a concept may be derived from several upper concepts, then it is referred to as a hierarchical structure or taxonomy. Compared to Thesaurus, ontology can be language-free; it means that Ontology deals with concepts that are independent of the language used to design them while Thesaurus deals with words that are expressed in a particular language.

Therefore, thesaurus cannot create new relationships between words, whereas ontology can do this .But finally, there is no clear distinction between taxonomy, thesaurus and ontology, and taxonomy can be considered as a particular case of ontology .In most of the ontologies, the taxonomic structure is used because it is better to certain features of ontology. Below are some examples of IS-A and non-IS-A relationships (Table 1) [8].

Table 1: Examples of is-a and non-is-a

IS_A relationships:	Non IS_A relationship
Liver Radiation Therapy IS_A Liver Cancer Treatment	Hysterectomy can _be_realized_with Ovarian Gland Removal
Liver Surgery IS_A Liver Cancer Treatment	Hepatectomy can_be_followed_by Liver Radiation Therapy
Hepatectomy IS_A Liver Surgery	Lymph Node Removal can_cause Lymphedema Of Arm

Another kind of hierarchical relationship in ontologies is "part of", and the ontologies that use this type of relationship are known as partonomies, such as anatomy ontologies [9]. In the design of ontology, the key points are to understandable and usable for professionals and non-professionals, as well as the use of different languages.For example, physicians are familiar with medical terms, and patients are not and also the most of the scientific texts or documents have been write in English. To solve these problems, we need to create an ontology that covers a range of professional and non-professional concepts as well as non-English languages. To better understand these issues, consider the following examples:

Lymphedema of Arm…………. (Professional- English)

Arm swelling…………………... (Lay – English)

STANDARDS

While ontologies provide a conceptual basis for the information exchange, standards create consistency in the information exchange between different systems and allow interoperability between systems.

The main standard for Interoperability in the SW is the Resource Description Framework (RDF). It is an object-oriented and Extensible Markup Language (XML) based standard developed to describe concepts and create documents in SW. XML is based on Unicode and Uniform Resource Identifier (URI) and also supports multiple languages .The URI is typically used to represent a location or address of sources, and the Uniform Resource Name (URN) to identify the source by name on the Internet. The schema is also a language to describe the structure and content of elements in XML documents.

The RDF schema is a standard tool for describing properties and data properties, which provides a mechanism for describing resource groups and relationships between these resources and is based on XML and XML Schema. Web Ontology Language (OWL) is the SW-based ontology language derived from the combination of the DARPA Agent Markup Language (DAML) and the Ontology Inference Layer (OIL). It is a languages to knowledge modeling in artificial intelligence. The structure of OWL is based on the OWL-DL and OWL-lite. The first is a grammar to describe simple hierarchies with simple constraints, and the latter is based on the descriptive logic that performs the reasoning and controlling the contradictions automatically [10-13].

MATERIAL AND METHODS

This review article aimed introduces the integration and standards that create the interactions between different systems of knowledge and therapy as the basis of the semantic web. The main sources of information were the literature review, Tehran University of medical sciences library and databases such as PubMed; Scopus; Web of Science and Google Scholar. Keywords such as semantic web, ontology, interoperability standard for search were used.

RESULTS

According to studies to achieve the SW, having appropriate ontology is very important. Creating ontology requires the following components:

Extended lexicon

A kind of dictionary in which there is not only the meaning of words, but also the rational relationships between terms. Thus, for the creation of ontology, all concepts are extracted from a dictionary in a particular discussion, such as objects or entities, subjects, verbs, and states, along with their dependencies [14].

Meta data

Data about data means information about data elements such as name, size, data type, length, field, and location.

Software Agents

Small programs that interact with the Internet or, in other words, perform tasks in accordance with the following steps.

- Access to domain knowledge
- Reasoning about their tasks
- Sending the tasks to other agents
- Interpreting received messages
- Decision making based on domain knowledge and collected information
- Making decisions in a meaningful way

In ontologies, agents are for extracting and combining information from different sources to answer questions. In fact, these agents can create the interaction between a user and a computer in the Web [9, 15, 16].

There are some tools to support the user to create an ontologysuch as TextToOnto, Text2Onto, TERMINAE, ASIUM, Ontologos, OntoLearn, OntoLT (Table 2).

Table 2: Types of ontologies

Type	Description
Upper Ontology	They are also called fundamental ontologies. In this type, there is a distinction between things that exist, such as objects, and things that happen, such as processes, and the ontologies are modeled better.
Domain Ontology	This kind of ontologies includes important topics of a particular domain, for example, for biology, physics or astronomy.
Reference Ontology	It is used for explicit display of the domain and usually created and developed without any specific application in mind. Reference ontologies are often used in high-level ontology to recognize the formal ontology of the domain.
Formal Ontology	Used for semantic coding based on logic. Therefore, computational or computerized inferences are made using automated reasoning.

Informal Ontology	It is The opposite of the formal ontologies. The informal ontology implies that the ontological diagnosis is not performed and the representation is done without the use of precise meanings.
Application ontology	When the reference ontology try to explicit representation of an aspect of the domain, usually uses the several reference ontologies to illustrate a particular applicable scenario. Also, additional information should often be added to the ontology to apply it.

Table 3 presents some editors are also used to create and maintain an ontology in a graphical way [1, 5, 9, 17].

Table 3: Ontology editors

Name	Application
OntoEdit	The most prominent editor in the field of business
Prote´ge	The most famous editor of academic ontology
KAON	It is not only a ontological editor, but also an open source Ontology management infrastructure for business applications

As shown in Table 4, there are ontologies in healthcare that play the role of interoperability standards and standard vocabularies for the accessibility of health data.

Table 4: Ontologies in healthcare

Name	purpose
Arden Syntax	A standard for representing medical knowledge
ICD-10	A classification for diagnostic codes.
CPT	A classification for diagnostic and surgical procedure codes.
LOINC	A general database for labs code and name, and clinical examinations.
GALLEN	Uses the language for displaying treatment terminology.
UMLS	Facilitates the retrieval and integration of information from a variety of sources and is used as a basic ontology in medicine.
SNOWMED	A reference terminology.
LinkBase	Facilitates the modeling of ribosome components and compares the results of the studies.
Gene Ontology	To display information about the role of genes produced by an organism
Riboweb Ontology	This system presents medical terminology by algorithms in an official domain ontology.

DISCUSSION

One of the most challenging problems in healthcare is the ability to interoperate between information systems. The interoperability is important because of facilitating the knowledge sharing in the complicated environment [18, 19].

When paper based medical records are archived in files, there was a collection of valuable information that there was no connection among them. In this way, the organization was rich in data but poor in information. By computerizing them in the form of an electronic medical record, all of databases with all of data formats such as structured data (e.g. surgical reports, radiology and pathology), unstructured data (e.g. medications, laboratory results), and visual data (e.g. radiological images) were integrated in the healthcare organization [14].

Interoperability between these heterogeneous structures is difficult and requires a medium for the information exchange. The SW uses ontologies to create a common language and interoperability standards [20, 21]. Some of ontologies were shown in Table 4 these are the interoperability standards and the standard vocabulary in the health care that can facilitate access to the necessary information by increasing the accuracy of searches on the web. Specifically, in searches, researchers encounter problems such as polysemy, ambiguity, and synonyms that increase and diffuse the results.

These ontologies add context to the patient's medical history, create linkage among diagnosis and procedure medications, laboratory tests and radiology examination automatically. As a result, queries are more effective and the results are closer to search terms [14].

CONCLUSION

In the research, SW provides a common framework for sharing and reuse of knowledge among applications and organizations. This sharing and reuse of knowledge improves scientific research through creating new ideas, testing different hypotheses from different aspects, facilitating the training of novice researchers and reduce the costs of information gathering. In fact, the SW makes relationship among different sources of data by data mapping.

In healthcare, SW, increasing the accessibility of medical information plays an important role in reducing medical errors. This information and knowledge sharing and semantic interoperability is a key factor in improving the quality of services provided to patients, promoting public health and improving the quality of health services management.

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