Modeling Medical Interventions Using the Semantic MediaWiki for use in healthcare practice and education

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Abstract

Social Software and particularly semantic wikis have been increasingly adopted by many online health-related professional and educational services. Because of their ease of use and rapidity of deployment, they offer the opportunity for powerful information sharing and ease of collaboration. Semantic wikis are Web sites that can be edited by anyone who has access to them. However, within medical intervention domain, certain important fundamental issues around development and evaluation have yet to be resolved. Thus, this paper proposes a Wikipedia-like Web-based tool to be used for describing and classifying medical interventions in order to plan and document patient care at a distance. Finally, this paper provides an overview of the ontology to be taken into account for the support of the Web-based tool.

1. Introduction

Semantic wikis are considered to replace traditional applications by allowing users to easily publish articles, images and video. They started as a response to the lack of free online medical information and function as a repository of medical information that could be easily accessed. They promise a future of collaboration by domain experts on the production of semantically linked and ontologically structured hypertexts which could enable accessibility to patients, doctors or trainees and the public. Moreover, in a Semantic Wiki, the aforementioned notion of a collaborative Wiki extends to the incorporation of “semantic technologies” like RDF, OWL, Topic Maps, or Conceptual Graphs, with the idea of exploiting the semantics of the terms (i.e. enrich existing navigational links with symbols that describe their meaning, that is semantic annotations), [1]. In a medical wiki, the group of editors creates and contributes with article reviews, disease definitions (symptoms, cure etc), clinical notes, medical images or video. Editors have the ability to alter content published by other editors and have their articles edited by others hoping that the wiki will finally converge into a widely accepted final version (which is still editable though if need be).

Some examples of using wikis for accessing and sharing specific health information by patients and clinicians are AskDrWiki (http://askdrrwiki.com), WikiSurgery (http://wikisurgery.com), Ganfyd (http://www.ganfyd.org - a free medical knowledge base that anyone can read but only registered medical practitioners may edit), Wikicancer (http://www.wikicancer.org) and Clinfowiki (http://www.clinfowiki.org – An encyclopedia of medical informatics sponsored by Informatics review). Recently, the World Health Organization has announced to use a wiki for the revision of the International Classification of Diseases to involve more people other than expert panels, a notion indicating that the strict taxonomy based classification work may be in need of less tight and strict approaches like folksonomies [2].

However, within medical intervention domain, there seems to be no semantic wiki that allows a true import of OWL data. Intervention domain is a key factor in patient survival and in the maintenance, rehabilitative, and preventive or chronic aspects of healthcare, like for example elderly care. Changes and new developments in healthcare delivery in the last decade have given rise to the need for a common framework of communication to ensure continuity of care for the patient moving between multiple healthcare settings and providers.

The purpose of this paper is twofold. First to allow for and present an easy and contemporary tool designed to aid doctors and patients in identifying interventions commonly associated with specific
nursing diagnoses. These interventions are the activities needed to implement and document care provided to the individual patient and can be used in varied settings from acute to community/home care. Secondly, the paper aims to show the obvious exploitation of this artefact in the medical education or general health professionals training sphere.

For this reason a “Wikipedia-like” web-based tool that provides an efficient method of organizing thought processes for clinical decision making, problem-solving, and delivery of higher quality, individualized patient care was implemented. When a patient enters this tool, whether as an inpatient, a clinic outpatient, or a home-care patient, various steps are set into motion. Data are collected, patient needs are identified (nursing diagnoses) and specific interventions are selected to assist the patient in achieving her goals.

So the structure of this paper is as follows. In section 2, the very idea of using the Semantic Media Wiki (SMW) is provided together with its architecture and semantic content. Section 3 deals with the ontology behind the wiki, while the next two sections are devoted into use cases of the tool, followed by a last section that discusses its exploitation in education.

2. Wikipedia-like Web-based tool

Wikis are a special form of web sites, in which users are able not only to read published content but are also able to add new information as well as to change existing information. The MediaWiki software [3] is a freely available tool which is used for setting up wiki sites in many companies. Due to its extensibility and the availability of 3rd party extensions, MediaWiki is used as the basis for the solution proposed in this paper. Moreover the freely available extension Semantic MediaWiki (SMW) [4] is the implementation of semantic wiki used in this work. SMW+ provides additional features over SMW in the area of usability. Examples are autocompletion, semantic toolbar, which simplifies text annotation, as well as an ontology browser for visualizing categories, instances and properties.

2.1. Architecture

The architecture of the tool is illustrated in Figure 1 and includes the following components:

- An ontology editor tool to build the ontology that is imported in semantic wiki (e.g. protégé).
- A reasoning unit to check the consistency of ontological data (e.g. pellet)
- The Semantic MediaWiki as a flexible knowledge management tool for semantic annotation of wiki content.
- The Halo extension of Semantic MediaWiki which provides additional features over SMW in the area of usability.

The tool is intended for doctors, patients and medical students. These users may use a Web browser to navigate through the semantic wiki tool user interface (e.g. they point their browsers to http://160.40.50.57/EXPO). The semantic wiki pages are hosted in an execution environment that is supported by a Web server, as well as, a data management server (implemented as a database management system, MySQL) that is part of the same environment. Communication log files remain stored in the local execution environment.

The wiki contains information about interventions and diagnoses in various domains which are described in the next section. Generally speaking, interventions represent doctor actions or behaviors. This is different from diagnoses which represent the patient’s actions or behaviors. The front end side with which the doctors patients and students interact comprises the semantic wiki SMW+.

The wiki covers several essential functionalities. First it allows doctors to monitor changes in the data via Semantic Notifications. Doctors get individual alerts about relevant events, e.g. when new interventions are available. Another aspect is the provision of a comprehensive view on the interventions which is encoded in the ontology. Browsing and navigating the ontology is enabled via the Ontology Browser and the Semantic Treeview. An appropriate semantic representation of the ontology enables to track the lifecycle of each intervention. The compilation of reports is achieved via semantic queries that can be executed via a custom query interface.

2.2. Semantic content

The wiki currently consists of 36 specific interventions. These types can be lumped into larger categories.

The “basic physiological” domain contains a variety of topical interventions dealing with such areas as activity and exercise management, elimination management, immobility management, nutrition support, physical comfort promotion and self-care facilitation.
The “complex physiological” area deals with care that supports homeostatic regulation. Areas under the umbrella of "physiological: complex" include acid-base management, circulatory care and mechanical assist device.

Another domain is “behavioral” intervention. These deal with care supporting psychosocial functioning and changes in lifestyle. Behavior modification, learning readiness enhancement and health education fall under this domain.

Care that supports maintenance of the family unit falls under the “family” domain. This particular domain deals primarily in birth and reproductive care, including interventions for electronic monitoring and high-risk pregnancy care.

The “safety” domain is for interventions that deal with harm prevention. One of the most common interventions within the safety domain is environmental management, which deals with monitoring and manipulating physical surroundings to maintain safety.

The domain that deals with proper use of the healthcare system is the aptly named “health system” domain. In this domain, interventions include proper use of hospital and clinical protocol, proper respiratory and medical history assessment.

For more widespread interventions, the “community” domain deals with care that affects a larger community. These group-based interventions include substance-abuse therapy, support for those involved in abusive relationships, the work of home health nurses and classroom-based health education.

3. Ontology in Semantic MediaWiki

For the purposes of the ontology creation, Protégé is selected for use as the authoring tool, because it has features that we identified as the most important to look for when selecting an ontology authoring tool [5]. First of all it is widely used, actively developed and supported and is open source (thus facilitates the replication of the creation process).

In addition, the OWL standard was selected for use as an ontology language. The OWL standard from W3C has become the de facto language for describing ontologies on the semantic web. OWL builds on RDF providing more expressiveness such as cardinality constraints and equivalence relationships [6].

Finally, with the help of the Gardening Framework of SMW, the ontology was imported in semantic MediaWiki which employs namespaces to distinguish several types of content pages.

The top level entity class of the ontology (Figure 2) is the MIC: MedicalInterventionClassification which contains various subclasses of interventions corresponded to different domains and represented by OWL classes. Each intervention OWL individual has several actions and links to diagnoses, represented by OWL object properties.

Semantically speaking, OWL individuals are represented by normal article pages. These pages typically constitute the majority of the wiki’s contents, mostly contained in the MediaWiki’s Main namespace.

OWL classes in turn, have natural counterparts in the wiki in the form of MediaWiki categories. The category system, which was introduced only in 2004 [7], quickly became the most important feature for classifying articles in Wikipedia. Categories are represented as pages within the Category namespace. They can be organized in a hierarchical way, but it is not possible to make a category contain other categories.

OWL properties, i.e. roles in description logic, do not have a counterpart in MediaWiki, and were introduced by the Semantic MediaWiki extension. OWL further distinguishes object-properties (describing relationships between two individuals) from data-properties (associating individuals with values of a given datatype), and a similar distinction is found in the Semantic MediaWiki.
4. Possible users

There are various target groups for this wiki. Firstly, doctors could use this tool in order to stay informed about the current interventions and their connection with specific actions. Recently, it has become less common to apply intervention methods from scratch. Instead, interventions are applied by adapting and/or combining the existing re-usable ones. Consequently, there is a kind of database of re-usable intervention methods, including their semantic information.

The wiki also could provide end users with a means to retrieve and share data about interventions and diagnoses. Furthermore, because this tool is public and is designed to contain drug information apart from interventions and diagnoses, the outcomes may be valuable for the pharmaceutical industries in order to promote their drugs.

Finally, research organizations and other working groups could use this wiki. Any researcher can publish his work as single unit in OWL format. Because data in such format can be searched by semantic web search engine, it offers a new channel for data sharing and retrieval that will accelerate scientific discovery as well as increase the researcher's visibility. Moreover, they can create new ontologies using the existing one as a source. So, for instance, researchers in programs with contemporary (clinical or business) interventions in elderly care and ambient assisted living (cf the LLM project: www.longlastingmemories.eu) which are usually powered by different technological artefacts [8] may use this tool to construct the particulars of their pilot interventions.

5. An indicative example of use

Consider a medical student who is preparing a presentation for his medical class on the topic of “interventions”. Suppose further that, like many students, she consults the English language Wikipedia. If she wants to collect information about various types of interventions and their properties, she will have to create a new document of her own and start typing or copying and pasting text on the basis of the Wikipedia text.

Consider now what is possible if this page has been transformed into a semantic wiki. One resulting enhancement that is a standard part of Semantic MediaWiki is a fact box at the end of each page that summarizes all of the facts in the article that have been captured by typed links. In addition to offering a concise overview of the facts in the article, the fact box makes it easier for the user to navigate systematically to related pages, which are ordered in the box according to the nature of the relationship.

A more powerful way of exploiting the semantics of the wiki is by querying the Semantic MediaWiki as if it were not only a web of hypertext, but also an intertwined database. Concretely, suppose that our student would like to start her research by creating a table that lists interventions along with their actions and their background information. She can then invoke the Query Interface shown in Figure 3 to specify the relevant category (“Intervention_Hierarchy”), and the two relevant properties (“Intervention has intervention action” and “Has background information”), as well as various parameters that will determine the exact form of the table. Since the student probably does not know in advance the name of each of these properties, the system includes an enrichment (autocompletion) feature: As the student types characters into the field for the desired property, the system displays all property names that include the substring that she has typed.

To continue with our scenario, suppose that the student would now like to find some additional properties. Since she does not have a particular property in mind, autocompletion would be of no help; so the student visits the Ontology Browser (Figure 4) to get an overview of the various properties that interventions can have. She types the word “Intervention_Hierarchy” into the filtering field and clicks on “Intervention_Hierarchy” in the Category Tree, thereby narrowing the information shown in the browser to instances of the category “Intervention_Hierarchy” and the properties of these instances. By clicking on “ABC Iceberg” in the middle section, she can see all of the properties that have been
annotated for that type of intervention, while noticing several properties that might be added to her table.

Although the functionality and interfaces presented in this scenario are only a fraction of those developed in our work, the scenario can serve as a background for a discussion of our experience in designing and testing these interfaces.

6. Conclusions

This paper has explained the construction of an ontology hierarchy that contains intervention information for use in health care practice. This ontology utilizes available descriptions and data from currently described interventions and diagnoses. However, the paper also presents a Wikipedia-like Web-based tool for the ontology, which basically enables possible users to browse, search and query it. Moreover, facilitating a Wikipedia-like web-based tool into the intervention domain allows users to describe the care received by the patient and to document the effects of that care on patient outcomes, thereby essentially constructing an instance of their intervention/trial. This has obvious benefits as it facilitates the comparison of care trials across worldwide settings and diverse databases.

Furthermore, it offers immediate health care education and training opportunities at various levels, with the continuing and/or the vocational one being in the main focus. That is, instances of intervention descriptions and uses may be easily turned into useful educational examples, which once coupled with other learning properties may form educational resources which may themselves follow certain ontological schemes [9] and taxonomical descriptions [10] in order to be used in the wider context of health care education [11].

7. References


[6] OWL language. Available at: http://www.w3.org/TR/owl-features/


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Figure 3. The Query Interface of the enhanced Semantic MediaWiki

The ontology browser lets you navigate through the ontology to easily find and identify items in the wiki. Use the filter mechanism at the upper left to search for specific entities in the ontology and the filters below each column to narrow down the given results. Initially, the flow of browsing is left to right. You can flip the flow by clicking the big arrow between the columns.

Press Ctrl+Space to use auto-completion. Ctrl+Space in Excel

Figure 4. The user looks for properties of interventions with the help of the Ontology Browser