

# A Multiple-Ontology Template-Based Query Interface for a Clinical-Guidelines Search Engine

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**ABSTRACT.** A major problem in the effective use of computerized clinical guidelines is fast and accurate access at the point of care. Thus, we developed the Digital electronic Guideline Library (DeGeL) and a set of tools for incremental conversion of free-text guidelines into increasingly machine-comprehensible representations, including a search and retrieval engine. In previous research, we have designed and implemented *Vaidurya*, a multiple-ontology, concept-based and context-sensitive search and retrieval engine that exploit the hybrid nature of guideline representation in the DeGeL architecture. While *Vaidurya* offers a wide variety of querying options, which was found effective in improving the retrieval performance, it may be sometimes restricted by the user's limited familiarity with guideline ontologies or her clinical background. We therefore describe the Template-Based Query Interface. A novel approach, which we implemented, enables the user to exploit the ontology-based search capabilities in *Vaidurya* without being familiar with the details of the underlying ontologies or of the concepts hierarchy used for classification.

## 1 INTRODUCTION

Clinical Practice Guidelines (CPGs) are a powerful method for standardizing the quality of medical care [1]. CPGs are a set of schematic plans for management of patients who have a particular clinical condition (e.g., insulin-dependent diabetes). Unfortunately, most CPGs are represented in free text, whether in paper or in an electronic format. Paper-based guidelines are relatively inaccessible to care providers at the point of care, while the free-text electronic format provides little support for automated retrieval of the guidelines potentially most applicable to the patient at hand.

Several clinical CPG formats, or ontologies (a knowledge-base schema that includes a set of concept types, their properties, and the relations among them), have been proposed in order to represent clinical guidelines in a structured or even machine-comprehensible fashion. Examples include ONCOCIN [2], EON [3], Asgaard (Asbru) [4], PROforma [5], GLIF [6], and GEM [7]. Each ontology specializes in a different kind of representation, for example *GEM* focuses on documentation representation, while *Asbru* specializes in the automated executable representation.

The **Digital Electronic Guideline Library (DeGeL)** [8] is a set of web-based software tools for incremental conversion of free-text CPGs into multiple CPG-specification representations (ontologies); the full architecture includes

also search and retrieval tools, a browsing tool, and runtime-application tools. Each CPG in the DeGeL library eventually undergoes a semantic mark up process, which is performed mainly by a domain expert, in which the CPG's text is labeled by one of the available ontologies implemented in DeGeL (such as Asbru or GEM). The markup process' main goal is to assist the knowledge engineer in transforming the guideline into a formal machine-comprehensible format, such as full Asbru. However, the semi-structured representation of the text, in which each segment represents a knowledge role (e.g., entry conditions) that can serve as a relevant context for search, is highly useful for accurate retrieval operations. The DeGeL library represents guidelines using a meta-ontology format. Ontology independent elements, such as documentary details and semantic classification indices, are common to every guideline, regardless of the lower-level ontology, such as Asbru, used to present the guideline's details. To classify guidelines, for purposes of efficient retrieval, seven semantic axes (concept taxonomies), based on MeSH [9] and the UMLS [10], are implemented in DeGeL. Each axis represents a major clinical aspect. Each Axis is implemented as a hierarchical tree of sub axes. Each CPG is indexed along one or more semantic axes, such as Disorders (e.g., malignant skin melanoma), Guideline specialties (e.g., oncology), etc.

A major current focus is on the retrieval of CPGs as a valuable tool to improve the adoption and integration of CPGs at the point of care, as part of the evidence based medicine approach. Electronic CPG repositories, such as the National Guideline Clearinghouse (NGC<sup>1</sup>) provide access to electronic guidelines in a free-text or semi-structured format.

In this paper, we first introduce the *Vaidurya* search engine. We describe *Vaidurya*'s powerful retrieval optional methods. We introduce the challenge in enabling a useable query interface exploiting *Vaidurya*'s search methods. We discuss the challenges facing designing such a system so that it will be easy to use and intuitive. Finally, we discuss our novel suggested approach: The Template-Based Query Interface.

## 2 VAIDURYA

Recently, we introduced *Vaidurya* [11], a powerful search and retrieval tool that uses three kinds of search methods: (1) *full-text search*, using standard key terms; (2) *concept-based search*, in which the user specifies a set of concepts and the logic relations within them, and (3) *context-sensitive search*, which exploits the semantic markup performed on guidelines in the DeGeL library or any other markup tool. The searcher can search for key terms only in the context of the text that exists within the scope of a particular semantic knowledge role.

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DeGeL has two guidelines representations, Source guidelines (GLS) and Marked up guidelines (GLM). GLS, an entity representing guidelines at their Full Text representation, which were downloaded from any website on the internet, using the DeGeL source ontology. The GLS ontology contains elements representing the metadata on the CPG and documentation details. GLM, an entity representing guidelines that were marked up, using the URUZ tool [8], represented by the DeGeL hybrid ontology, which includes the markup ontology that the guideline was marked up to and also metadata and documentation elements referring to the DeGeL markup documentation.

CPGs are marked up at different ontologies and classified along the DeGeL axes, thus Vaidurya was built as an infrastructure that enables the storage for any kind of guideline ontology or axis representation for a guideline. Vaidurya Search Query supports any kind of query (concept, context or full text) at any ontology and any axis. A Search Query is a set of queries obtained on a group of chosen elements from a specific ontology and sub axes from one or more axes, this combination describes the group or single searched guideline. The query is created using a query interface.

A recent formal functional evaluation performed on Vaidurya showed a significant improvement in the retrieval performance when context-sensitive or concept-based search used compared to traditional full text search [12]. These results highlight the contribution and effectiveness of the context-sensitive and concept-based search in addition to the full text search.

### 3 THE VAIDURYA QUERY INTERFACE CHALLENGE

Using the current search interface, implemented in DeGeL, at each type of search, GLS or GLM, presents both benefits and limitations. On the one hand, it offers the user a wide variety of extended attributes at the varying ontologies elements, where each element can be queried. On the other hand, such a detailed Search Query Interface enforces a long interface, resulting in a complicated and hard to use interface. Examples and more details are shown in [8,12,14].

Dealing with complex interfaces and designing them to be usable has become a major challenge due to the growing sophistication of systems and information overload. Additionally, since computerized systems have become much more accessible to a variety of users, designers are faced with the challenge of designing interfaces that will suite various users with varying levels of experience and that are at the same time usable. A preliminary experiment was conducted on a small group of participants to evaluate the usability of the Query interface. The participants included expert physicians familiar with DeGeL, expert physicians who weren't familiar with DeGeL, physicians, Med-school students, nurses and regular users (with no clinical education). All the participants reported that the Query Interface was too detailed and too long. We had learned that each group of users had different interests in clinical guidelines and different information needs. Furthermore, each group of users had a different level of clinical knowledge in general, and different kinds of experiences with clinical practice guidelines in particular. Another influencing factor was the user's familiarity and experience with DeGeL and CPGs

ontologies. We noticed that each group used different kinds of ontology elements when querying with correlation to their knowledge and experience in clinical guidelines. For example, regular users searched by using only simple elements like Source Full Text and Title while expert physicians queried also the classifications axes and internal marked up contents like Entry Conditions and more. All participants agreed that in order to perform a search they prefer an interface that offers only a small subset of the ontology elements, which they will use most of the time, based on their knowledge and their current search needs.

One way of dealing with the problems discussed above is by customizing the interface. Customization enables users to manage the functionality of the interface in a way that may better suit their needs. Customizations are usually changes made by the user or on behalf of the user, for instance by a system administrator. It is advantageous, given that it enables users to express their preferences regarding some of the functions and appearances of the systems. Nevertheless, studies [18,19] have shown that users don't customize. One reason is that the changes in the system are up to the user to make and the interface is a tool that is manipulated directly by the user [15]. In order for the user to make the customization he is required to learn an additional set of functions, which may impose additional cognitive load on the user and interfere with the performance of other tasks. Additional reasons relate to the difficulty of the customization or to the fact that users often find the default interface as sufficient.

We decided to implement a customized query interface in which a user can customize a query interface based on his personal search preferences. However, in this case a super-user performs the customization for the future use of other users. The super-user is familiar with Vaidurya and the intended group of users information needs, and therefore can create an interface containing a subset of ontology elements and chosen axes that will suit the users needs and requirements. This in turn eliminates the difficulties often associated with customization, made by the end user. Actually in our case the end user (e.g., searcher) doesn't customize but uses customized interfaces.

### 4 THE VAIDURYA CUSTOMIZED QUERY INTERFACE

The Vaidurya's Customized Query Interface (VCQI) (see [13] for more information) is designed and customized by the super-user for a given group of users, having common search needs. Imagine clinicians in a certain hospital's department, who are probably interested in the same group of guidelines. These guidelines are classified along one or more DeGeL axes representing their specific clinical interests. A super user at this department will create a VCQI suited to his colleagues needs after performing some searches at Vaidurya using the Full Ontologies search. From this point onward, colleagues in that department can use the newly created VCQI. Also, other users outside the authoring department might find the VCQI useful. One example is the need of internists in a certain department of medicine to retrieve guidelines regarding congestive heart failure. A super user

will create a VCQL that will enable retrieval of heart failure guidelines according to common clinical knowledge needs relevant to heart failure. This might include retrieval of heart failure guidelines pertaining specifically to systolic dysfunction, to nutritional management of heart failure etc. Thus, the VCQI created will be very useful for the clinical staff in that department, and will probably also address the needs of clinicians from other clinical departments.

A pilot evaluation was conducted on the VCQI using a group of medical students. The evaluation showed that the customized query interfaces were more useful and brought better results relative to the basic search, searching only within the full text and the full query interfaces [14]. However, the evaluation has also demonstrated that the interface was still overloaded and included many objects not clear or familiar to many users due to their lack of knowledge regarding many ontologies. This complicates the interaction with the interface and defies many human computer interaction (HCI) guidelines (see [16,17]). Therefore, in addition to the customized interface we decided to apply a template based query interface. This way the interface represents the information in a more familiar easy to use manner.

## 5 The Vaidurya Template Based Query Interface

We developed and implemented a novel approach for querying, in which a super user designs and creates a more abstracted query interface, compared to the customized query interface. The objective was to enable users to perform queries without having to be familiar with any ontology element, nor concept hierarchies. The Template-Based Query Interface (TBQI) offers the user a query interface, which describes the searcher's needs in a natural language template. The end user needs only to enter his keywords and preferences to complete his specific search. The advantages in this approach will be explained in the next sections.

### 5.1 The Vaidurya TBQI Creator

The creation of a new TBQI is accomplished in a few steps. First the super user is required to choose a proper name for the template, which should reflect the requested contents of the search results. Naming the template has an important role, as choosing a specific TBQI, based on its name, reflects the user current search needs. As a result, the user will encounter a list of interfaces from which he will choose the appropriate template. Following the naming of the TBQI, the super user fills a short detailed description describing the purpose of the search and specifies the intended users (i.e.;

patients, nurses, medical students, resident and attending physician etc').

The next step is made using a visual designer. Figure 1 shows the TBQI Creator, in which the super-user creates a new TBQI in a few simple steps, implemented as a wizard. First, the super-user chooses the type of search, a Source Ontology (GLS) or Markup Ontology (GLM). The chosen ontology are then displayed from which the super-user chooses the contexts. In the case of Markup, the user has to select one of the markup ontologies implemented in DeGeL (e.g., Asbru, Gem...).

The super user can choose from four types of Template elements:

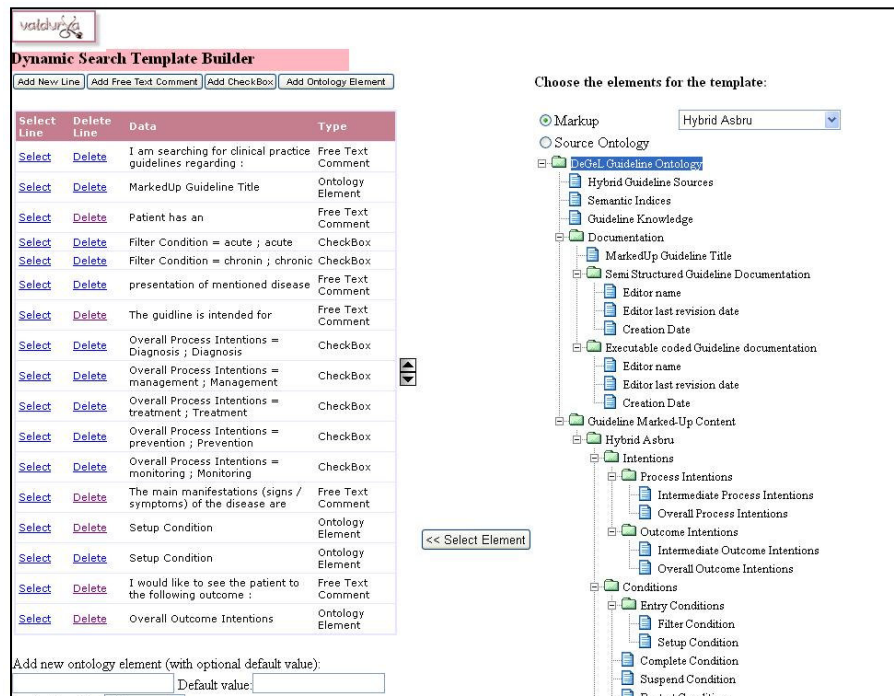
- **Ontology Element** - Executed as a text box, where the searcher will enter his keywords.
- **Free Text Element** - The natural language parts wrapping the template.
- **New Line** - Executed in the search form as an end line.
- **Check Box** - An element which will be executed as a check box, where the searcher has to check or not, confirming the phrase the check box represents.

The Check Box can have several meanings, for example a specific value for an ontology element, or a chosen concept from one of the DeGeL axes. The Check Box element will have a phrase in natural language representing the search need. The table on the left side in Figure 1 represents the design of an example TBQI. Figure 2 demonstrates the resulted TBQI, which is a result of the TBQI designed in Figure 1.

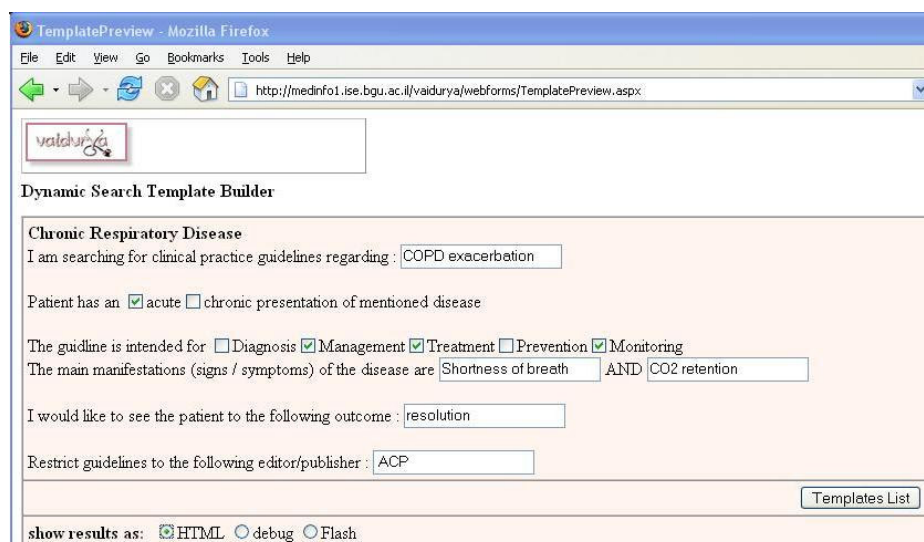
To conclude, the TBQIs attempts to deal with the complexity of using such systems by enabling users to interact with an interface more easily by presenting them with familiar terms and more natural language. The TBQI enables user s with no familiarity with CPG ontology representation and lack of clinical knowledge (e.g., patients) to search. This gap of knowledge is being overcome through the super user knowledge implemented in the TBQI.

## 6 Conclusions

The mark up process and classification a CPG goes through in DeGeL gives us the outstanding opportunity to query, using the context-sensitive and concept-based methods. We described the challenge encountered using these methods. We suggest here a novel approach to overcome the lack of experience and familiarity in guideline ontologies representation and clinical knowledge, required for the use of these methods. While this approach is implemented here for the search of CPGs it can be extended to any other clinical literature which is represented in a structured fashion or classified along concept hierarchies. Pilot experiments had shown a great contribution of this approach for searchers resulting in improved search results.



**Fig.1.** Design and creation of a TBQI. Domain knowledge engineer selects Hybrid ASBRU markup terms (right column) Terms are mapped to medical terms either as textboxes or checkboxes. Terms are inserted in between natural language free text snippets. Textboxes may be assigned by predefined default values according to context. In the above example, the Filter Condition in the guideline marked-up content will appear as a text box asking the physician about symptoms and signs.



**Fig. 2.** End-user (searcher) interface of TBQI – User (healthcare provider) fills in free text or marks checkboxes in a simple natural language interface. There is no need to be acquainted with the specific markup ontologies or guideline terms. Designer may adjust complexity and detail level for different intended users and searches.

## 7 Future Work

We are in the process of creating a set of TBQIs and a set of gold standard queries, which will be the base of a formal evaluation of the usability of the Template-Based-Query Interface approach, as part of the entire evaluation of the customized and basic query interfaces in Vaidurya.

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