Demonstration of DeGeL: A Clinical-Guidelines Library and Automated Guideline-Support Tools

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ABSTRACT. Using machine-interpretable clinical guidelines to support evidence- based medicine promotes the quality of medical care. In this demonstration, we present the Digital Electronic Guidelines Library (DeGeL), a comprehensive framework, including a Web-based guideline repository and a suite of tools, to support the use of automated guidelines for medical care, research, and quality assessment. Recently, we have developed a new version (DeGeL.NET) of the digital library and of its different tools. We intend to focus in our demonstration on DeGeL's major tools, in particular for guideline specification in Web-based and standalone fashion (Uruz and Gesher), search and retrieval (Vaidurya and DegeLook) and runtime application (Spock), and to explain how they are combined within the typical lifecycle of a clinical guideline.

1 INTRODUCTION

During the last 20 years, there were multiple efforts to provide automated support to evidence-based medicine by formalizing clinical guidelines (GLs) into machine interpretable formats [1,2]. GLs represented in a machine-comprehensible, formal format can be applied by computerized agent as a tool to support physician decisions at the point of care or as a tool for retrospective quality assessment and research. Several guideline-specification ontologies such as GLIF, GEM, and Asbru were developed to represent guidelines in a formal and machine interpretable format. In our research, we focus on the Asbru ontology as our target specification ontology.

1.1 The DeGeL Framework and it's Hybrid Meta Ontology

In order to support the automation of guideline-based care, there is a need to convert the GL from its free-text representation into a machine interpretable format. The guiding principle followed in our research is specifying GLs through the collaboration between expert physicians (EPs) and knowledge engineers (KEs). EPs transform the clinical knowledge represented in free text GLs into intermediate, semantically meaningful representations while KEs convert these intermediate representations into a formal, machine-interpretable representation.

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To convert clinical GLs into a formal representation, we have developed the Digital electronic Guidelines Library (DeGeL) [3], which uses a hybrid representation, in which all intermediate and final formats are stored within the knowledge base. The intermediate representation levels have additional benefits; the semi-structured level is crucial for context-sensitive search of GLs; the semi-formal level supports application at the point of care without an access to an electronic medical record (EMR) being available.

DeGeL's Hybrid Meta Ontology includes elements common to all guideline ontologies (e.g., Asbru, GLIF). Semantic classification axes that index GLs by several conceptual indices (e.g., disorders, therapies) are an example of a common element.

2 DEGEL.NET

To overcome several limitations of the web-based architecture of the previous version of DeGeL, we have developed a new version (DeGeL.NET) of the digital library and of its different tools. Our goal when designing the new version was to create a distributed, web-service based, open architecture implementation according the Service Oriented Architecture design specification [4]. This new approach grants the ability to develop a suit of tools for guideline specification, retrieval and application. In addition, the open architecture may host alternative tools for guideline specification and application. The DeGeL.NET implementation includes the following main modules: (1) a knowledge base server, (2) a guideline-specification tool (Gesher), (3) a runtime application engine for clinical guidelines (Spock).

DeGeL's server allows development of rich client tools by using web-service methods to retrieve and edit guidelines in the knowledge-base. The server's architecture is assembled of the following modules: (1) a guideline database that contains the overall schema to support the hybrid multiple ontology representation, (2) a module which is responsible for guideline-knowledge creation, reading, updating, and deletion, (3) a new guideline search engine, named DeGeLook, which is intended to replace the current search engine, Vayduria [5], which facilitates context-based and concept-based search methods for enhanced guidelines retrieval, (4) an authorization module, which supports the group-based authorization model, and (5) a web-service API that enables the guideline knowledge-base server to accept client requests and to orchestrates multiple steps, in order to perform the requested transactions.

We have developed additional client tools to allow DeGeL's administrators to perform tasks to maintain the guideline library. OntologyBuilder supports the task of acquisition and maintenance of the hybrid ontologies stored within the knowledge-base of DeGeL. DeGeLock is a client tool developed for the administration of the authorization module. The library administrators use DeGeLock to create and manage groups of users with various roles and profiles, these users typically collaborate in specifying new guidelines within the knowledge base, but they also include users who only search the library or who have administrative functions. AxisBuilder was developed for maintaining the conceptual hierarchical indices (e.g., therapies, disorders) used for semantic classification of the guidelines.

2.1 Gesher – A Graphical Framework for Specification of Clinical Guidelines

Gesher is a client application designed to support the process of incremental guideline specification at multiple representation levels according to target specification ontology. It is intended to supplement and eventually replace the Uruz Web-based markup tool [3] whose feasibility for use by expert-physician editors was demonstrated in an extensive evaluation [6]. The specification process is performed by decomposing the guideline's protocol into sub-guidelines specifying the target ontology knowledge roles (e.g., the Asbru filter conditions, the GLIF eligibility criteria) for each of these sub-guidelines. Gesher provides graphical interfaces to enable gradual knowledge acquisition process performed in collaboration of an expert physician familiar with the clinical knowledge and a knowledge engineer familiar with the target ontology. This collaboration, which includes specification of the guideline clinical consensus, is critical for achieving high quality specification [6].

When considering the clinical knowledge embedded in a clinical guideline, we define two types of knowledge. The first is procedural knowledge representing the steps of the protocol and is described using the specification ontologies. The second type is declarative knowledge, which consists of the concepts in the protocol and their definition according to the context in which they are relevant (e.g. in the context of Hypothyrd guideline, Hypothyroidism is defined as TSH $\leq$ 0.4 IU/ml and FT3>4.2pg/ml). To accomplish the task of representing declarative knowledge at formal level, Gesher uses the interface of temporal abstraction knowledge acquisition tool, which is one of the tools used in the IDAN temporal abstraction mediator to patient data [7], thus enabling the application of this knowledge at run time by querying the temporal patient database by the Spock runtime guideline application engine. Gesher has access to the MEIDA system [8], a comprehensive framework for linking medical decision-support systems to clinical databases, which includes a search engine for controlled medical vocabularies such as ICD-9, CPT and LOINC. Gesher uses the MEIDA system to enable the use of standards terms from controlled medical vocabularies when defining the clinical terms of the guideline, thus making it sharable and reusable across multiple local clinical-database platforms.

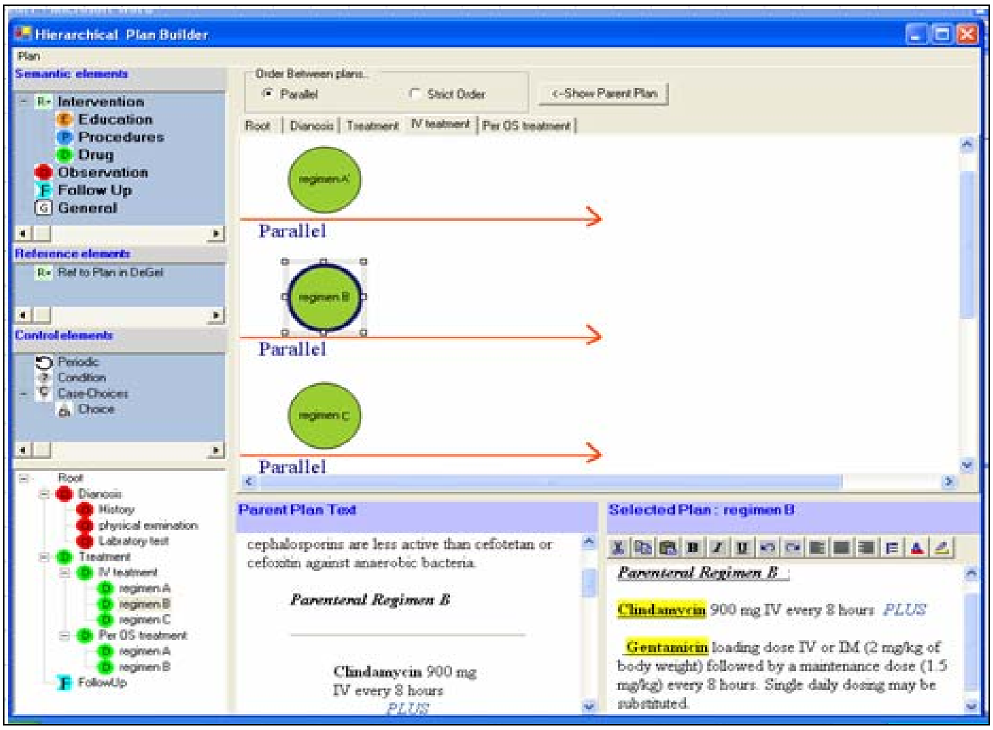

Figure 1. The Hierarchical Plan Builder in Gesher, specifying the procedural aspects of the guideline. In this case a plan for IV treatment of PID composed of three different regimes that should be performed in parallel.

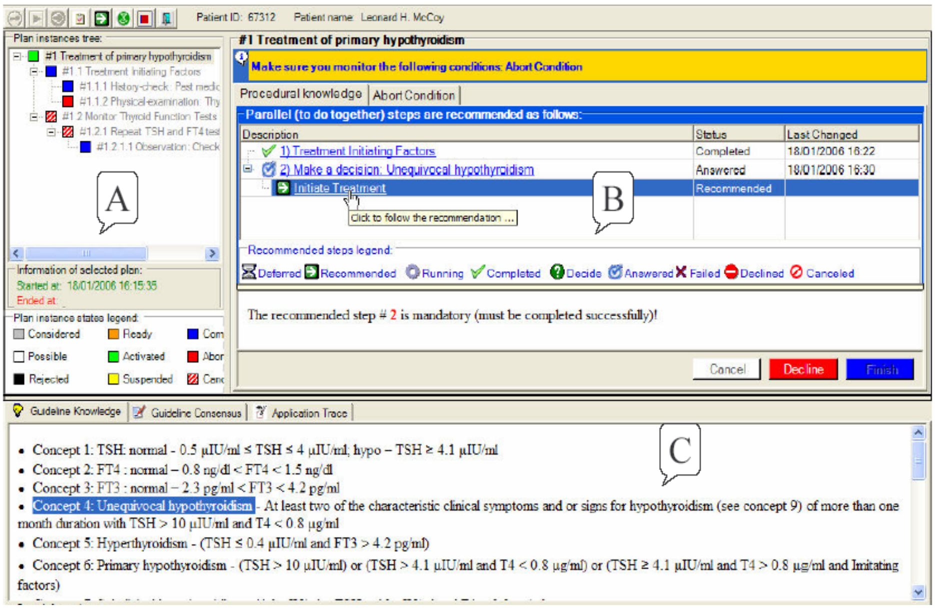

Figure 2. The Spock run-time guideline (GL) application module's default interface: The left panel (A) displays the plan instances that were created during GL application as a hierarchy; the top center panel (B) displays the relevant knowledge-roles of the current selected plan-instance, each knowledge-role in separate tab (e.g. Procedural Knowledge, Abort Conditions); The bottom panel (C) displays guideline information such as definitions of concepts used in the guideline, a detailed outline of the guideline consensus, and the progress of the application using the tabs Guideline Knowledge, Guideline Consensus and Application Trace in that order.

2.2 Spock – Runtime application of Hybrid-Asbru clinical guidelines

We support runtime application of intermediate-represented Hybrid-Asbru GLs, with or without an available electronic medical record (EMR), capitalizing on the DeGeL framework as a knowledge repository of machine-interpretable guidelines and on the IDAN architecture for access and sophisticated querying of heterogeneous clinical-data repositories. The new approach was implemented as the Spock system [9], which provides the necessary functionality to support the task of applying clinical guidelines at the point of care.

The Spock system's architecture includes the Spock engine responsible for the actual interpretation of the knowledge encoded in the intermediate-represented guidelines, and a Spock server, which provides remote services to store and retrieve the history of guideline applications from a GL application log repository, and remote external services, such as the DeGeL server's services for retrieving GL's knowledge. In a preliminary evaluation using three different clinical GLs and several patients' records for each GL, The Spock system was found capable of applying semi-formal Hybrid-Asbru GLs, with or without an accessible EMR [10].

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