A framework for representing and executing a clinical practice guideline for the management of high blood pressure in pregnancy

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Introduction: In this work we describe a framework for representing and executing clinical practice guidelines (GLs) and we focus on a particular application. The core of the framework is a tool called new-GUIDE for representing a GL with both a graphical language (for the flow of actions) and a formal language for building rules and abstractions, both qualitative and temporal. It is well known that reaching a formal representation starting from a text is a difficult task, leading to different representations for the same text. In order to facilitate this task, we propose Unified Medical Language System (UMLS) as a standard for terminology and an ancillary tool developed by us, Medical Text Markup (MTM), that is an XML-XSLT-based mark-up tool for the HTML-based free text representation of the guideline.

Methods: The "National High Blood Pressure Education Program Working Group's (NHBPEPWG) report on high blood pressure in pregnancy" proposes a clinical practice guideline for the classification, differential diagnosis and management of patients with high blood pressure in pregnancy.
It provides the tasks to be performed for managing patients and also provides the principles on which those tasks are based. We have done a formal representation of the tasks and abstractions mentioned in the guideline using UMLS, MTM and GUIDE.

Markup of the guideline
According to the semantic types of UMLS, the medical terms are classified into Event and Entity. Event is defined as a broad type for grouping activities, processes and states and Entity as a broad type for grouping physical and conceptual entities. In a system for representing and executing task-based guidelines, most of the tasks belong to three of the the UMLS semantic types "Laboratory Procedure", "Diagnostic Procedure" and "Therapeutic or Preventive Procedure" .These fall under the semantic type of "Health Care Activity" and all the other semantic types are mapped into these, in order to understand, represent and execute the guideline in the clinical setup.

The general rule of MTM is that the flow of the text is maintained in the markup, and the markup highlights sequences of "terms", within the text, that define "paths". Thus, each path defines a vector with the constraining concepts. For example,
Hypertension --- that is present and observable before pregnancy
Hypertension --- that is diagnosed before the 20th week of gestation

are two paths derived from the text of the guideline that restrict the number of patients to be considered. The terms which are not constraining their parent term are put in a separate path starting from the parent term.
MTM is as much as possible compliant with UMLS: a "term" is a concept found in the vocabulary of the UMLS with its UMLS ID. If the term is not found on the terminology server the user can define his own term. The first-level semantic type for the term mentioned in UMLS is the parent of the term and is marked by "S-" and after the semantic type the term is marked by "T-" followed by its UMLS-ID. If the term is not found on the terminology server, user must choose a UMLS semantic type for it. Thus, each term should have a semantic type as its parent element. The two paths mentioned before will appear on the markup in this way:

S-Disease-or-Syndrome-T-Hypertension-C0020538 ----> S-Organism-Function-T-Pregnancy-C0032961

S-Disease-or-Syndrome-T-Hypertension-C0020538 ----> S-Physiologic-Function-T-Gestation-NOS-C0312415

Temporal constraints and, in general, logical operators present in the text are not represented in the markup explicitly, because MTM deals only with medical concepts related to each other.The result of the markup is that all the medical concepts mentioned in the GL are put into the proper context, and this facilitates the subsequent formal representation.

Formal representation of the guideline

The semantics of new-GUIDE consists of 8 basic element types: task, decision, wait, monitoring, synchronisation, start, stop, arcs.

Its main features are:

1. definition of composite tasks
2. two types of decision:
    a. deterministic, i.e. guided by rules
    b. non-deterministic, i.e. let to the physician that can call for a decision theory-based support system, if any (like decision trees and belief networks)
3. possibility of representing the fundamental control paths: parallel, sequential, iterative tasks
4. the use of standard terminology servers
5. representation and use of modular pieces of knowledge
6. a formal language for the definition of both abstractions and rules
7. different types of abstractions
    a. qualitative
    b. temporal
        i. state
        ii. gradient
        iii. stationary
        iv. complex
8. a parser for the interpretation of rules and abstraction definition, that produces results reading a virtual patient record, i.e. data mapped into a fixed-structure database from the legacy healthcare system

9.A drug server, that gives the general indications for choosing a drug based on the pathology, other drugs administered and the past efficacy or adverse effects of a drug on the patient.

10.Guideline Elements Model (GEM) specifications are incorporated, which help in storing and organising the heterogenous information contained in GLs.

Among these features, we illustrate here the reusability of some abstractions in the representation of the above-mentioned guideline.

Modularisation and abstraction

Here, we take the example of the diagnosis of pre-eclampsia. The symptoms in pre-eclampsia which accompany increase in blood pressure is represented as an abstraction "PreEclampsiaSymptomsExcludingBP" which is defined as "Proteinuria>=2.0#gram/day.or.Dipstick=2.or.Dipstick=3.or.Serum-creatinine-level>>1.2#mg/dl.or.Platelet-Count<<100000#cell/mm3.or.Microangiopathic-Hemolytic-Anemia.or.Alanine-aminotransferase-increased.or.Aspartate-aminotransferase-increased.or.Persistant-headache.or.Cerebral-Disorder-NOS.or.Visual-Disturbance-NOS.or.Persistant-epigastric-pain".

The blood pressure levels for diagnosis of pre-eclampsia is represented as "PreEclampsiaSymptomBP" which is defined as "Systolic-Blood-Pressure>=160#mmHg.or.Diastolic-Blood-Pressure>=110#mmHg".

Thus the combination of the above rules is ruled to diagnose Pre-eclampsia based on the findings, i.e. "PreEclampsiaDiagnosis" is defined as "PreEclampsiaSymptomBP.and. PreEclampsiaSymptomsExcludingBP".

The reason for marking two separate abstractions is that the second one is associated with the "Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure" which, in general, defines the stages for hypertension and the method of blood pressure determination. Supposing to have represented this guideline within our framework, the modules and abstractions defined can be reused in the high blood pressure in pregnancy guideline.

Conclusion: This work shows an application where the GL-markup and the use of a standard terminology facilitate the representation of the GL itself, the reusability of modules among different GLs and the rationale behind each task during GL execution.