

Computerization Framework for Clinical Practice Guidelines by Extending the XML Guidelines Element Model (GEM)

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Abstract. Contextually sensitive and semantically related evidence-based knowledge play an important role in decision-making. Clinical practice guidelines (CPG) are being developed to provide a rich source of up-to-date knowledge of evidence-based best clinical practices. Such knowledge assists healthcare practitioner in specific clinical circumstances at their decision-points. In many studies, it was shown that the effectiveness of CPG could be improved with their computerization. In this paper, we present our CPG-knowledge computerization framework that has been developed and implemented along the lines of knowledge management approaches. This framework adds context, semantics and related meta-information to the CPGs knowledge content using an extended-knowledge component ontology and UMLS. It also transforms them into a set of structured 'extended-knowledge components'. These extended-knowledge components constitute a 'CPG knowledge base', which is used for providing assistance at point of care.

Keywords. CPG-computerization, knowledge modeling, ontology, UMLS

1. Introduction

Decision making process heavily depends on knowledge and information. The quality of decisions at point of care is enhanced by evidence-based knowledge, which is contextually-relevant and semantically-related for the problem at hand. Clinical practice guidelines are regarded as a rich source of up-to-date knowledge of evidence-based best clinical practices [1, 2]. In essence, "Clinical-practice-guidelines (CPGs) are originally textual documents, usually structured as a set of clinical situations, for which evidence-based therapeutic recommendations are provided" [1]. To make better use of such CPG heterogeneous knowledge, it is necessary to computerize them and then incorporate them in a clinical decision support system (CDSS) [2]. Different formalisms have been used for representing CPGs, such as GLIF [3], Arden Syntax [4], EON [5], GEM [6, 7]. Consequently, different approaches have been used for encoding and knowledge modeling of CPGs to transform them into computer understandable format [1, 2, 4, 8, 9]. Most of the techniques represent CPG knowledge in a form of "If-then-with" rules.

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We argue that such computerization lacks sense of important attributes: (i) context sensitivity (incorporating contextual relevancy mechanism), (ii) semantics correlation, and (iii) XML structured information about CPG documents [9]. For example, the intention of a ‘chunk of CPG knowledge’ can be identified as a ‘*Myocardial Ischemia diagnoses*’. A medical phrase “*Ischaemic heart disease*”, from the chunk of CPG knowledge content, can be enriched with the following information: (i) its semantic type, which is “*Disease or Syndrome*”, (ii) contextual impact factor, since it appears under “*action to be taken*” statement, (iii) the vocabulary source, which is SNOMED CT, (iv) the best final mapping of this phrase, which is “Myocardial Ischemia” and (v) the UMLS score, which is “the strength/confidence of the mapping of the original phrase to the corresponding SNOMED CT term. Incorporating such attributes to CPGs knowledge content helps in identifying and retrieving CPG knowledge that is contextually-sensitive and semantically-correlated for the problem at hand.

We present, in this paper, our CPG-knowledge computerization framework that has been developed and implemented along the lines of knowledge management approaches. We extend the GEM model, which is a document model for CPGs, with additional attributes. Our CPG-knowledge computerization framework does not transform CPG knowledge into “If-then-with” rules. It adds context, semantics and related meta-information to the CPG knowledge content by using ‘UMLS’ and ‘extended GEM model’. It structures and transforms a CPG into a set of *extended-knowledge components (Ex-KCs)*.

2. GEM Extension

GEM is an XML-based guideline document model that can store and organize the heterogeneous information contained in ‘practice guideline documents’ [1, 3, 4]. The most important element of GEM is the “knowledge component” section. It stores and categorizes the recommendations of CPG to constitute the essence of practice guidelines. Details about the GEM model can be found in [6, 7]. GEM has several limitations. It is a simple abstraction of the guideline document that makes it dependant to extrinsic system to apply it in ways that are useful. GEM does little to resolve the ambiguities presented in many guidelines [1]. Although GEM provides quite good number of elements, additional attributes and relationships are needed to adequately encode guidelines. Such additions help applying the knowledge modeling technique for computerization. We extend GEM at knowledge component level based on our encoding strategy [10]. In our work, GEM extension is carried out by our *extended-knowledge component ontology (Ex-KC-O)*.

3. Extended-Knowledge Component Ontology

We have developed the extended-knowledge component ontology (Ex-KC-O) to extend the GEM model. This ontology adds additional attributes and elements to each ‘knowledge component’ section of the GEM. These additional attributes and elements cope up with context, semantics and meta-information related to CPGs knowledge content. It also redefines its structure to be compatible with our encoding strategy. This ontology helps to create the instances of Ex-KCs. The Ex-KC-O provides “has-a” relationships among different elements. It has a hierarchical structure and content, as

described below. The major extension in GEM model was in adding, ‘*element name*’, ‘*medical term element*’, and *five attributes for each medical term element*. The extensions are emphasized below in italic.

The top level element of the Ex-KC-O is a “Knowledge component” that has one attribute “*ID*”. This “Knowledge component” has three different elements: (i) *Knowledge component name*, (ii) *Knowledge component medical terms*, and (iii) “Recommendation”. The “Knowledge component medical term” element has five attributes: (i) *contextual weight*, (ii) *ID*, (iii) *semantic type*, (iv) *vocabulary source*, and (v) *original name*. Every “medical term” for different elements in the ontology has these five attributes. The “Recommendation” element has five sub-elements: (i) “*Recommendation name*”, (ii) *Recommendation medical term*, (iii) “Conditional”, (iv) “Imperative”, and (v) “Linkage”. The “Imperative” element has one sub-element, that is an “*Imperative medical term*”. The “Conditional” element has three sub-elements: (i) “*Conditional medial term*”, (ii) “Decision variable”, and (iii) Action. The “Decision variable” has four elements: (i) “*Decision variable name*”, (ii) “*Decision variable medical term*”, (iii) “Decision variable value”, and (iv) “Decision variable desecration”. The “Action” element has four sub-elements: (i) “Recommendation strength”, (ii) “Action description”, (iii) “*Action medical term*” and (iv) “*Action text*”.

4. CPG-Knowledge Computerization Framework

The CPG-Knowledge Computerization Framework, depicted in Figure 1, uses the *Ex-KC-O* and transforms a CPG into a set of *Ex-KCs*. We can formally represent the result of this process with Eq. 1, where a CPG is represented by ‘C’ and an *extended-knowledge component* is represented by ‘Ex-KC’.

$$C = \{Ex-KC_1, Ex-KC_2....Ex-KC_n\}$$
 (1).

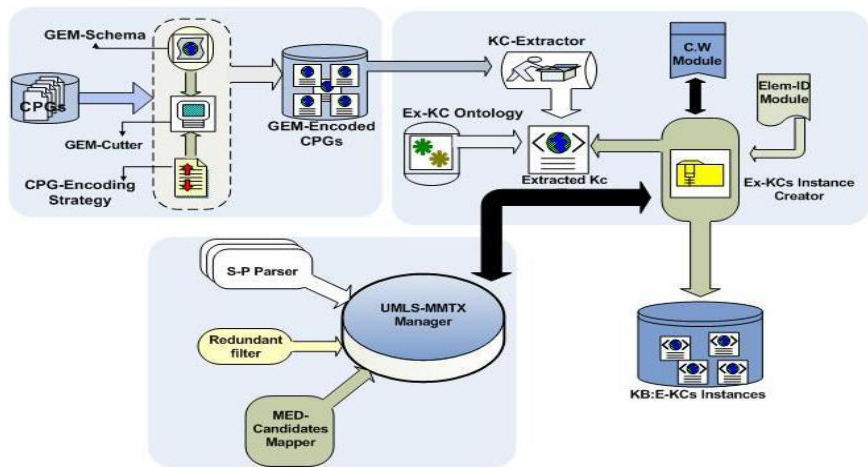


Figure 1. CPG-knowledge computerization framework

The functionality of our framework could be divided into three phases. In first phase, CPGs are marked based on our Encoding strategy [10]. This process produces a GEM-Encoded CPG, which is compatible with the knowledge modeling technique of our framework. GEM-Encoded CPG is passed to “Knowledge-Component-Extractor”

(KC-Extractor) to extract each knowledge component separately. In the second phase, extracted knowledge components are used by an “Ex-KCs Instance creator” module to create the *Ex-KCs* knowledge base. This module applies ‘Ex-KC ontology’ to create *defined-Ex-KC-structure*. In the third phase, the “Ex-KCs Instance creator” module works with different additional modules to add *meta-information*, *context*, *semantics* and *IDs* to each Ex-KC component. The additional modules are: (i) Contextual weight (CW) Module, (ii) Elem-ID Module, and (iii) UMLS-MMTX Manager. The contextual weight for medical phrases and terms, under different elements, is assigned by “CW Module”. The function of “Elem-ID Module” is to create automatic IDs specific to each element type and knowledge component. The “UMLS-MMTX Manager” uses three modules: (1) “sentence noun-phrase parser”, (2) “MED-Candidates-Mapper”, and (3) “Redundancy Filter”. The “UMLS-MMTX Manager” carries out the following tasks: (i) parsing sentences into noun medical phrases, (ii) retrieving a “best-final-mapping” of medical concepts from MeSH and SNOMED (iii) extracting *meta-information* for these medical phrases and (iv) filtering the redundant medical phrases.

5. Results and Discussion

We have applied our computerization technique to different CPGs and have successfully computerized them. In this paper, we present an example of the computerization of “Acute coronary syndrome 2006” CPG.

Acute management of chest pain

Getting to hospital

Chest discomfort at rest or for a prolonged period (more than 10 minutes, not relieved by sublingual nitrates), recurrent chest discomfort, or discomfort associated with syncope or acute heart failure are considered medical emergencies. Other presentations of ACS may include back, neck, arm or epigastric pain, chest pain, sweating, dizziness and palpitations. Myocardial infarction, unstable angina and pulmonary embolism, which are also life-threatening conditions, may present with similar symptoms. Prompt recognition and treatment of ACS is essential to reduce morbidity and mortality. Health care providers should refer high-risk patients to the nearest appropriate health care facility for appropriate management of myocardial infarction. Health care providers should refer patients who are at low risk of myocardial infarction to a primary care provider for further management. Patients should be reassured that chest discomfort from benign sources is unlikely to be life-threatening.

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Computerization Results:

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KC ID="ACS_06_za.xml_KC1">
  <KC.name>Acute management of chest pain</KC.name>
  <KC.MedTerm CW="0.5" ID="ACS_06_za.xml_KC1">
    OrgName="Chest Pain" SemType="Sign or Symptom"
    Vsources="MSH, SNOMEDCT" score="1000">Chest Pain</
    KC.MedTerm>

  <DecisionVariable ID="ACS_06_za.xml_KC1_R1_C1_dvl">
    <DV.name>Chest discomfort</DV.name>
    <DV.MedTerm CW="1.0" ID="ACS_06_za.xml_KC1_R1_C1_dvl">
      OrgName="[D]Chest discomfort" SemType="Sign or Symptom"
      Vsources="SNOMEDCT" score="1000">[D]Chest discomfort</
      DV.MedTerm>
    <D.value>at rest or for a prolonged period</D.value>
    <DValue.MedTerm CW="0.25" ID="ACS_06_za.xml_KC1_R1_C1_dvl">
      OrgName="Prolonged periods" SemType="Finding"
      Vsources="SNOMEDCT" score="983">Prolonged
      periods<DValue.MedTerm>
    <DecisionVariableDescription>(more than 10 minutes, not
      relieved by sublingual
      nitrates)</DecisionVariableDescription>
    </DecisionVariable>
  
```

Figure 2. An excerpt of a CPG (left) and results from the CPG knowledge computerization (right)

Figure 2 (left) shows the excerpt of the CPG knowledge content and Figure 2 (right) shows an excerpt of the CPG computerization. We compared our approach with the computerization techniques presented in [1, 2, 4, 8]. In these techniques different methods are used to represent CPG knowledge in “If-then-with” rules with complex encoding schemes that require substantial manual intervention. Such computerizations need specific rule execution engines to be developed. Rules are fired if exact decision variables, defined in decision logics, are matched. This puts constraints on GPs, when using a CPGs, to choose right decision variables in order to get relevant information. Such techniques do not make use of context, semantics, and meta-information related to CPG knowledge contents. In addition, some of the techniques are CPG format dependent [1], which are hard to be used for different CPGs format.

We have developed generic encoding technique that can be applied to any kind of CPGs. Our encoding strategy is simple and many tasks, such as atomization of decision variables, actions, other elements and manual creation of *IDs*, are not needed. The Ex-KC instances are created automatically. Our technique adds context, semantics and meta-information pertaining to CPG knowledge content that helps retrieve relevant-knowledge from CPGs knowledge bases.

6. Conclusion

We have identified and discussed the problem regarding to computerization of CPGs. We have developed CPGs computerization framework that extends the GEM model by using *extended-knowledge component ontology* and transforms CPGs into extended knowledge components – Ex-KCs. The resulting Ex-KCs are enriched with context, semantics, and meta-information, retrieved from UMLS. These extended knowledge components constitute the CPG knowledge base, which is used for the retrieval of CPGs knowledge for providing assistance at point of care.

We are currently working on an information retrieval algorithm that will allow GPs to specify their information needs in terms of *medical phrases* and *medial terms* and to automatically retrieve relevant knowledge from the computerized CPG.

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