A Knowledge Management Framework to Morph Clinical Cases with Clinical Practice Guidelines

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Abstract

In this paper we present a knowledge management framework that allows the automatic linking/mapping of contextually and functionally similar medical knowledge that may originate from different sources and be represented in diverse modalities. Our tacit-explicit knowledge morphing framework supports the extraction of tacit knowledge from past cases stored in a case-base and maps it to corresponding explicit knowledge stored in clinical practice guidelines. The novelty of our approach is inherent in the fact that it allows practitioners to simultaneously refer to explicit knowledge—i.e. clinical practice guidelines—and experiential knowledge—i.e. past clinical cases. Here we present the system design and intended functionality of our knowledge morphing framework.

Keywords:
Knowledge Management, Clinical Practice Guidelines, Clinical Cases, Tacit Knowledge

1. Introduction

Medical knowledge can be differentiated along the lines of *explicit* and *tacit knowledge* [1, 2], where each knowledge modality provides a specific kind of input in addressing a clinical problem. The emergence of knowledge management as a discipline has highlighted the importance of capturing and operationalizing knowledge to support decision support, learning/training and improving operational workflows and outcomes [3, 4]. This has precipitated the development of methodologies, tools, and frameworks to capture the different knowledge modalities, given their inherent existential and operational constraints, and an attempt to automate the captured knowledge through knowledge management systems. We note with interest that the current knowledge management systems are largely designed to deal with a single knowledge modality, for instance some variation of explicit knowledge represented as either documents, guidelines/workflows, symbolic rules and so on; or a type of tacit knowledge represented either as cases, scenarios or peer discussions [5,6]. Given the diversity of knowledge modalities that encompass any given topic/problem it is reasonable to demand access and use of all available knowledge, irrespective of their representation modality, to derive a knowledge-mediated solution.

Typically, medical practitioners tend to make use of a single knowledge modality—either explicit or tacit—when solving a problem, as most decision support systems do not support the synthesis of heterogeneous knowledge sources. The prevailing situation leads to a knowledge gap in clinical decision support systems. In our work we attempt to address this knowledge gap by developing a knowledge management framework that allows the automatic synthesis of contextually and functionally similar knowledge elements albeit in different modalities. The objective is to provide practitioners 'holistic' medical knowledge that has its origin in both tacit and explicit modalities of knowledge. For instance, whilst referring to past clinical cases that withhold the tacit knowledge, clinicians should be able to relate them to explicit knowledge resources such as clinical practice guidelines/medical literature or vice versa.

In this paper, we firstly introduce the novel concept of *knowledge morphing* to characterize the mapping of contextually similar knowledge modalities. To demonstrate the working of the proposed knowledge morphing framework, we present a system that (a) captures clinical case-based tacit knowledge in terms of structured case representation with respect to a case-based reasoning system; (b) computerizes Clinical Practice Guidelines (CPG) in the XML-based Guideline Element Model (GEM); and (c) automatically links user-specified aspects of a clinical case with related and relevant clinical evidence within a CPG.

2. The Case for Knowledge Morphing

Knowledge morphing is defined as "the intelligent and autonomous fusion/integration of contextually, conceptually and functionally related knowledge objects that may exist in different representation modalities and formalisms, in order to establish a comprehensive, multi-faceted and networked view of all knowledge pertaining to a domain-specific problem" [7].

In medicine, the need for leveraging all possible resources of medical knowledge is paramount, as there is the need and realization to give clinical care that is grounded in best evidence. From a pragmatic decision-support point of view, what medical practitioners require is "comprehensive, contextually-relevant knowledge that is both congruent with the evolution of the patient and at an appropriate level of abstraction" [7]. We contend that knowledge gaps in clinical decision making can be addressed by linking heterogeneous knowledge modalities through a knowledge morphing framework. In the past, knowledge morphing has been successfully achieved by linking CPG with related clinical evidence published in medical articles at PUBMED [8]. Further literature search also reveals work directly or indirectly related to the concept proposed here [9-14].

3. Our Research Methodology

In this section we present the detailed design of the morphing system proposed in this research work. The explicit modality of knowledge used in this context is clinical practice guidelines and the tacit modality of knowledge which is morphed with the explicit side is past clinical cases. Our goal is to be able to link these two different modalities of clinical knowledge by leveraging upon the contextual similarities of both modalities. Clinical practice guidelines are computerized (referred to as C-CPG) and the clinical cases are rendered computable using some case base reasoning representation (referred to as CBR-CC). The knowledge contained in CPG is strictly explicit and in accordance with the belief that it advocates the practice of evidence based medicine [15]. On the other hand, clinical case are tacit in nature because it captures clinical episodes which depicts the expertise of the expert. Our research methodology identifies a sequence of steps that involve both the transformation of the knowledge resources into formats that render them computable, and the forging of morphing linkages between the C-CPG and CBR-CC as illustrated in figure

1. Linkages between the two modalities lead to the following situations:

C-CPG to CBR-CC: In this case, the user wants to find corresponding experiential and tacit knowledge for some aspect of a CPG in question. The user, therefore, highlights the C-CPG content in question for which corresponding tacit knowledge, in terms of clinical cases, within CBR-CC is sought. Based on the normalized medical terms identified within the selected C-CPG content we generate a term-based search query for selecting the relevant CBR-CCs. CBR-mediated case similarity assessment methods that cater for both numeric and text based features are used to establish the similarity between the search query and the problem-description component of the CBR-CC.

CBR-CC to C-CPG: In this case, the user wants to find the clinical evidence for some clinical action noted in the CBR-CC. In this case, a set of case-defining feature-value pairs are selected by the user to form the basis for establishing the linkage with specific elements of C-CPG. The case-defining features are transformed to a search query using a standing information retrieval based vector support model. The search query is applied to the C-CPG with pre-set similarity measurement criterion, and sections of the CPG that relate to the search query are retrieved.

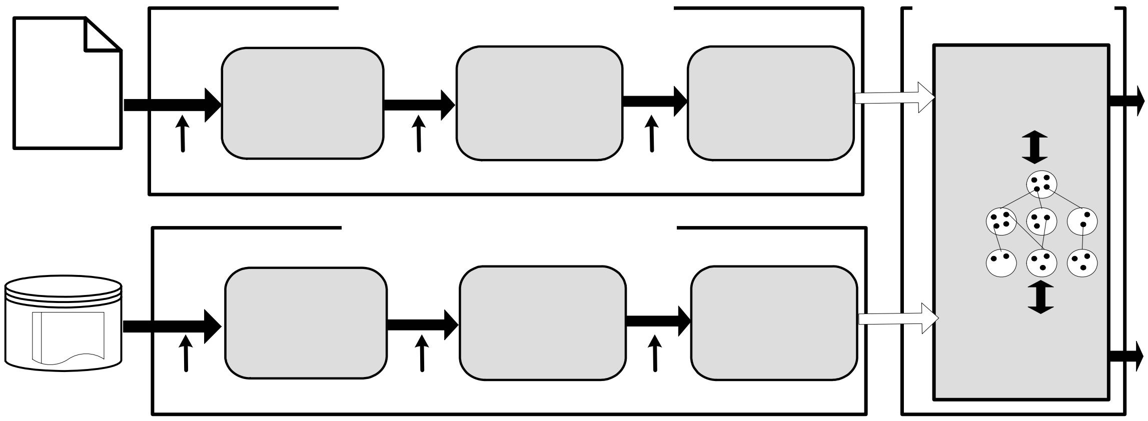

Figure 1: Schematic of our Knowledge Morphing methodology

We explain below some of the steps of our methodology in detail:

3.1 Operationalization of Explicit Knowledge

The explicit modality of knowledge used here are clinical practice guidelines. Clinical Practice Guidelines (CPG) are systematically prepared statement to help the physician with best decision making with regards to a certain medical condition. As mentioned earlier, the knowledge contained in CPG is explicit in nature and synonymously referred to as evidence-based guidelines. There are various guideline representation models which include the Arden Syntax, the Asbru model, the EON model, the GLIF model, the PROforma model, the GUIDE model, the GASTON mode, the Guideline element model (GEM) model etc [16]. GEM was developed at the Yale Center for Medical Informatics and was designed to provide structure for marking up any CPG in XML. In our work we use the Guideline element model (GEM). We convert the textual CPG using the Guideline Element model (GEM). The guideline selected for use here is the evidence-based guideline for weaning and discontinuation of ventilatory support (www.rcjournal.com/online_resources/cpgs/ebgwdscpg.asp). This guideline broadly covers recommendations for the management of mechanically ventilated patients, assessing the possibility of weaning the patients, managing patients who have failed spontaneous breathing trials, role of tracheotomy and the role of long term care facilities for such patients. Keeping these in mind, our domain expert (who is a fellow in pulmonary and critical care medicine) has provided us with clinical cases covering the above mentioned scenarios.

3.2 Operationalization of Tacit Knowledge

The tacit modality of knowledge used in this context is clinical cases which contain the innate knowledge of medical experts. Though the majority of healthcare knowledge is found in published journal articles, structured reviews, and practice guidelines; it is strongly believed that the tacit knowledge of the expert also contributes significantly towards optimal decision making [17-18].

The operationalization strategy used here is simple but effective which uses the clinical cases as the tacit modality of knowledge. Cases are marked up using XML tags to represent case structure illustrated in figure 2, as verified by the domain expert. This has also been proposed and successfully implemented in literature [19]. The objective here is to convert a text-based case into a format such that it could be mapped with the knowledge components in the CPG.

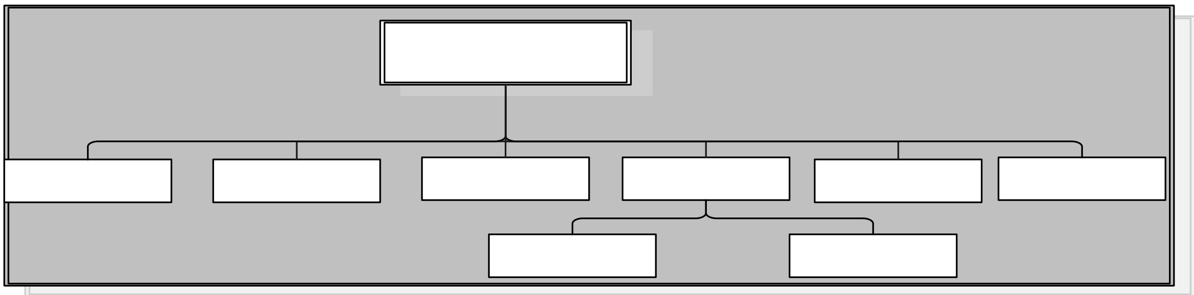

Figure 2: Data Type Definition of a generic Clinical Case

3.3 Morphing of explicit and tacit knowledge

Morphing of explicit and tacit knowledge modalities will involve (a) understanding and establishing a conceptual mapping of the DTD of a clinical case and GEM tags of the CPG; (b) developing an input module for interfacing with the user; (c) search query generation and execution; finally (d) displaying resultant output.

The idea of drawing a conceptual mapping of CPG elements to corresponding clinical case elements (performed by a domain expert) is to relate corresponding elements of these two different knowledge modalities, both refereeing to the same problem domain, in order to facilitate knowledge morphing. Once that is done then we will be required to build an interface with the user whereby the user can select text from the CPG or the case for which supplementary information is being sought. For text selected, we need to normalize the terms to standardized biomedical vocabulary and determine semantic types for each term. The Meta Map Transfer tool- MMTx is used to normalize terms before generating query, that is find synonyms of the MeSH(Medical Subject Headings) terms and find semantic types of the selected terms. The MMTx program takes as input sentence and separates it into phrases, identifies the medical concepts and assigns proper semantic categories to them according to knowledge embedded in UMLS. The output of MMTx would give us the MeSH terms together with UMLS semantic types. All these tools are downloadable from the UMLS Knowledge Servers found at NLMs website which are made available for research purposes only. [www.mmtx.nlm.gov/].

Once the candidate terms are identified, search query needs to be generated. The search query generation strategy is adapted from the original work by Abidi et al with respect to the BiRD system [20]. The BirD search strategy is as follows: (a) categorize queries based on a set of a priori defined query types [21]; (b) the search query is a combination of query type and candidate MeSH terms. Search query should only comprise of MeSH terms thus leading to the generation of optimum search queries [22]. The Search query generation is summarized as follows: (a) Parsing the string through MMTx for determining semantic types - query categorization; (b) Parsing of string through MMTx for identifying synonyms or alternate terms - query expansion; (c) Filtering out words which are not MeSH terms, i.e. the terms which do not have a definition in the MeSH vocabulary identifying them as extras and stripping them off. Also, terms which have semantic types other than the ones identified in the process of conceptual mapping of CPG and cases are also omitted. – term filtering; (c) For terms which already have semantic types identified, compose query to look up that string in the associated XML tags (according to semantic type category). Thus the candidate terms are used to generate queries generated using XQuery Language - query composer. Finally the result from the execution of the query is displayed for the user to review.

4. Conclusions and Future Work

Here we have presented a novel approach for linking of semantically, contextually and functionally similar knowledge element, albeit in different knowledge representation modalities, to realize a holistic knowledge resource for a particular medical problem. This paper presents an interesting working of the knowledge morphing concept in order to supplement explicit forms of knowledge with tacit knowledge and vice versa. This can further be extended to morph other modalities of knowledge or even more than two modalities at the same time. The work is still underway and therefore complete implementation details and evaluation which will be carried out with the help of the domain expert has not been covered in this paper.

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