Towards Evidence Adaptive Clinical Decision Support System

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***Abstract*—Current Clinical Decision Support System (CDSS) systems are designed to adhere to the knowledge of domain experts stored in their knowledge bases and are incapable to contemplating the referential support of evidence from online literature. In literature, an overwhelming amount of biomedical information is available as text documents which can be retrieved automatically and can be used as evidence support in clinical decision. Evidentiary support not only help in clinical decisions but also increases the confidence level of clinicians by keeping them up-to-date with new knowledge. In this paper, we elaborate the motivation, architecture, and methodology of evidence adaptive CDSS.**

I. Introduction

CDSS and Evidence based systems have long been used in clinical domain for clinical practice as a support to the clinicians in order to make better clinical decisions. Individual clinical expertise and best available external evidences complement each other and good doctors use them in combination, and neither alone is enough [1]. Without clinical expertise, even excellent external evidence may be inapplicable to, or inappropriate for an individual patient. Similarly, without current best evidence, only clinical expertise cannot provide the ultimate confidence over clinical decision as highlighted in [2]. The research evidence persuades the health professionals to pursue the care plan and decision with higher level of confidence. The full promise of CDSSs for facilitating evidence based medicine will occur only when CDSSs can "keep up" with the literature [3]. It is not surprising that most clinicians consider the research literature to be unmanageable [1] and of limited applicability to their own clinical practices.

Clinicians face a lot of barriers to reach to the credible information suitable to the context. They spent a lot of time to fulfill the searching parameters required by searching functions. Additionally, when they found the relevant information, they have no established infrastructure to manage the results conveniently in order to use efficiently in future scenarios. The big challenge is the right formulation of input queries to result in relevant evidence retrieval to be appraised and applied in clinical practice. The credibility of resources repositories adds to the challenge of automated acquisition of evidences.

The proposed Evidence Adaptive CDSS is composed of a comprehensive set of methods to cope with the challenges of evidence adaption from credible online resources. This covers both input request manipulation and output response handling ranging from query formulation, evidence acquisition, appraisal, and application. The ultimate goal of proposed work is to automate the process of evidence adaption in order to save clinicians time spent unnecessarily on manual question design and information management. The proposed system is designed and developed for cancer domain more specifically head and neck cancer (HNC) as a part of Smart CDSS [4, 5].

The inclusion of research evidence into clinical decisions varies with respect to situation and context. Conceptually, the evidence adaption follows the same 5A's cycle as mentioned in [6], however, implementation makes the scenario different. A user in clinical setup with CDSS implementation needs an approach for evidence differently than from the user having no CDSS implementation. The automation and integration at different levels bring uniqueness to the approach and pose challenges at the same time. The proposed approach takes into account the challenge of automated evidence adaption and integration with CDSS. It automatically fetches the current evidence from online credible journals available through PubMed service based on the questions formulated from rules of knowledge base (KB) of CDSS.

II. Background and Motivation

We have worked previously on a large scale project titled as "Smart CDSS" [5]. Smart CDSS is a clinical decision support system that provide diagnostic and treatment recommendation for chronic disease patients such diabetes and cancer. It has prototype implementation for HNC disease in one of the leading cancer hospitals [7]. The design philosophy of Smart CDSS is the standardization of knowledge base for shareability and interoperability. It utilizes HL7 Arden Syntax represented in medical logic module (MLM). An MLM encapsulates knowledge as software module that triggers an action based on data event generated at healthcare system [8]. Currently, the knowledge base of Smart CDSS utilizes expertise of the experienced domain experts (physicians). The proposed approach adds evidentiary support to the KB of Smart CDSS as shown abstractly in Fig. 1.

Domain expert creates the knowledge and it becomes part

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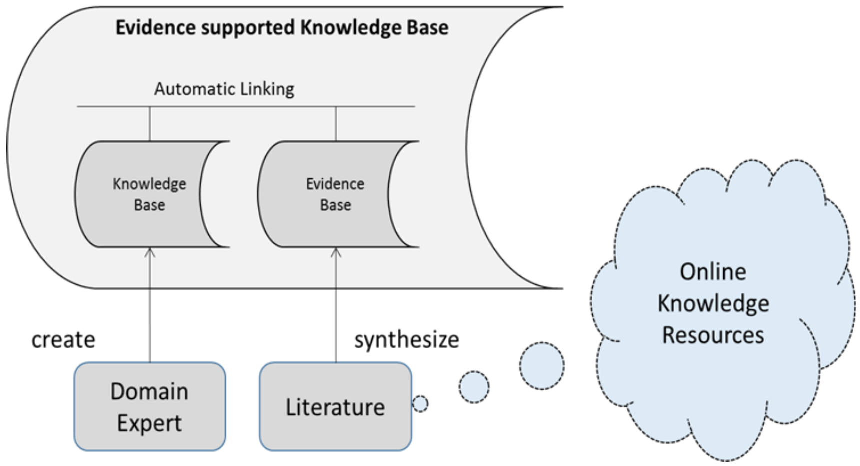

Fig. 1: CDSS knowledge base linkage with evidence base synthesized from online resources

of knowledge base. On the other hand, evidences are synthesized from the literature and become part of evidence base. A rule in knowledge base is linked with one or more evidences and vice versa. The proposed idea is evolved from our initial idea titled as "KnowledgeButton" [9].

III. METHODOLOGY

The methodology of the proposed approach involves several components to achieve the overall objective of evidence adaption. The detailed architecture is shown in Fig. 2 which is composed of major components including; query formulation and augmentation, evidence search, appraisal, and application.

A. *Query Formulation*

Getting better results from searching operation depends on mechanism of building the correct input query. Queries are built either automatically by the system or manually by the user. In both cases, the queries require close attention to formulate in order to get relevant output. In this paper, we focus on automated part of the architecture. Two kind of situations occurs while interacting with CDSS.

1. CDSS returns generate recommendation requested by actuating the required knowledge rules
2. CDSS fails to generate recommendation due to lack of the knowledge rules

As described in Fig.2, the input request is run on the knowledge base and infer the decision for diagnosis or treatment or any intervention in the scope of CDSS. For a decision to infer, a rule (caller MLM) is fired which may contain sub-rules (calling MLMs). The actuated rules (fired rules) are fetched, parsed and clinical terms are extracted to generate the query. The terms are transformed into standard terms if they are not already in standard form. The MLMs in Smart CDSS are already encoded in SNOMED CT vocabulary and transformation is not necessary. The extracted terms are connected using AND connector to formulate the basic query Q. The detailed algorithms of automatic query construction from MLMs is described in one of our previously published papers [10].

B. *Query Augmentation*

Query is augmented with domain context, synonym terms and target resources. Domain context provides the known information about the domain. For example, in HNC domain, we add term "head neck cancer" as prefix to the query. For synonym terms, we created synonym dictionary with the support of domain experts. Each term in query Q can have multiple alternative terms which are appended to the corresponding terms with "OR" connector. Adding context and synonyms minimizes the possibility to miss the important documents. Evidence searching component manages the communication with online resources using search engines such as PubMed based on the query. Resources are appended at the end of augmented query to guide the information retrieval function. If resources are more than one, they are connected with "OR" operator among themselves. The augmented query is transformed into proper URLs required by target search engine. We use PubMed search engine which accepts URLs in a special format provided with Entrez API [11]. For searching from PubMed, we have various methods provided by Entrez API, such as eSearch, eFetch, eSummary etc. We need to wisely use these methods in order to achieve the required results. eSearch method is used for basic search, while eFetch method returns the documents (for the PMIDs already searched with eSearch method). Similarly, eSummary method returns the summaries for the PMIDs given by eSearch method. The methods like eFetch and eSummary are utilizing the output of eSearch method by keeping the history and environment variables active. We can also maintain the previous histories in order to avoid the second-time retrieval of documents. No matter what method is activated, we need to hold the response for further manipulations.

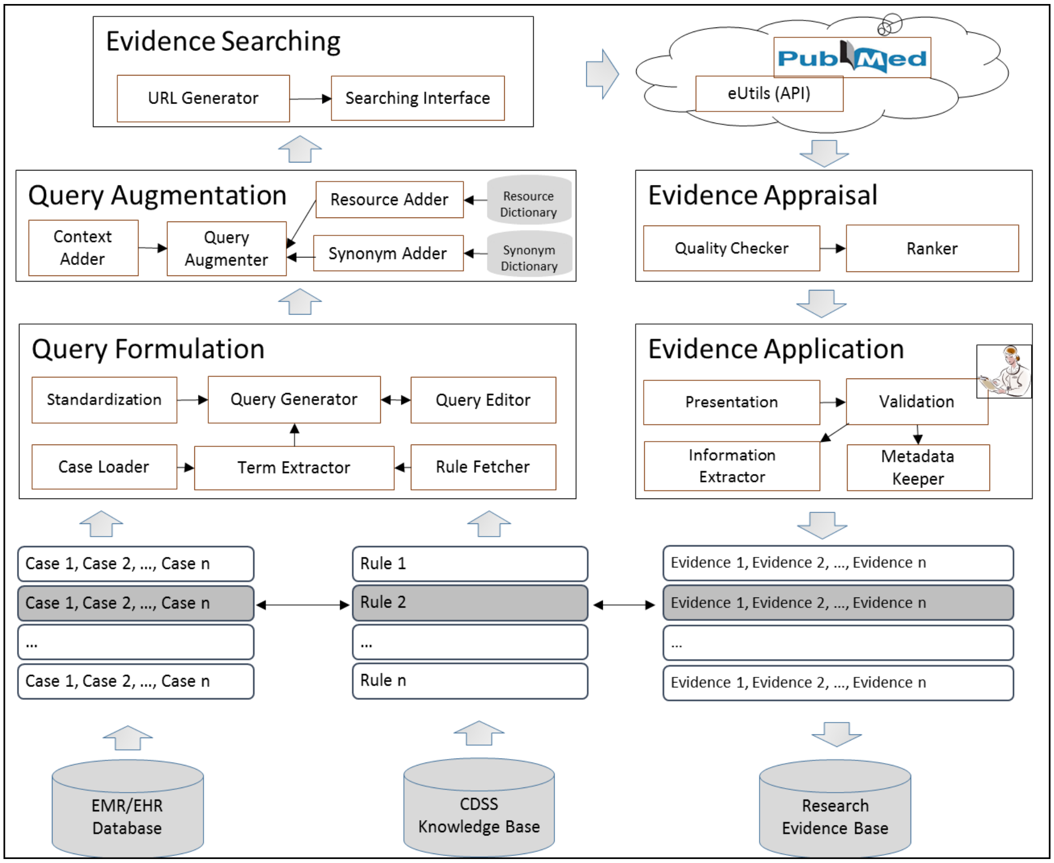

Fig. 2: Proposed System Architecture for Evidence Adaptive CDSS

C. *Evidence Appraisal*

Majority of the journals in PubMed publish abstracts in structured format including background, methods, results, and conclusion sections. Evidence Appraisal component checks the data features and meta-data features to identify the quality evidences from large set of retrieved evidences. Only those evidences that passed the quality check are selected for validation and ranking with the help of domain expert. PubMed return results using its own information retrieval strategy, however, most of the times the result-set includes large number of evidences that need to be check again to reduce the evidence set by filtering out the less relevant documents. The evidences in the final filtered set are presented to the domain expert for validation to rank them as "strong evidence", "moderate evidence", "weak evidence", and "not relevant".

D. *Evidence Application*

The validated evidences have the potential to use as a reference to the rules in knowledge base of CDSS. Moreover, the same validated set of evidences can be utilized for enhancing the knowledge base by adding new or modified existing rules. The meta-data of validated evidences is recorded as referential evidence set for the actuated (fired) rule. Next time when same rule is fired, these references are populated as supported evidences and only evidences are retrieved that are new to this list. The meta-data other than title includes PubMed Identifier (PMID), authors' name, journal name, date of publication, publication country, and link to the reference on PubMed. Hypothesis and rules generation from the validated evidences is out of scope of this paper.

E. *Evaluation Criteria*

The propose methodology is evaluated at two levels: automatic appraisal and manual appraisal. For automatic appraisal, we devised a statistical model that identifies the quality evidences. Only the quality evidences are passed to the user for manual appraisal. In manual appraisal, the user further segregates among the quality evidences by picking the most appropriate and applicable evidence.

IV. CONCLUSION

The proposed evidence-adaptive CDSS is envisioned to be the most convenient approach to use in clinical setup for improved, up-to-date, and research informed decisions. In this paper, we described the architecture and methodology of evidence adaption from online resources through the use of methods of automatic query formulation, augmentation, searching, appraisal, and application. We also discussed the evaluation criteria, which we plan to investigate in future by performing experiments.

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References

1. Sackett, D.L., et al., *Evidence based medicine: what it is and what it isn't.* Bmj, 1996. **312**(7023): p. 71-72.
2. Straus, S.E., J.M. Tetroe, and I.D. Graham, *Knowledge translation is the use of knowledge in health care decision making.* Journal of clinical epidemiology, 2011. **64**(1): p. 6-10.
3. Sim, I., et al., *Clinical decision support systems for the practice of evidence-based medicine.* Journal of the American Medical Informatics Association, 2001. **8**(6): p. 527-534.
4. Hussain, M., et al. *Clinical decision support service for elderly people in smart home environment*. in *Control Automation Robotics & Vision (ICARCV), 2012 12th International Conference on*. 2012: IEEE.
5. Hussain, M., et al., *Recommendations Service for Chronic Disease Patient in Multimodel Sensors Home Environment.* Telemedicine and e-Health, 2015. **21**(3): p. 185-199.
6. Leung, G.M., *Evidence-based practice revisited.* Asia-Pacific Journal of Public Health, 2001. **13**(2): p. 116-121.
7. Sultan, F., et al., *Development of an in-house hospital information system in a hospital in Pakistan.* International journal of medical informatics, 2014. **83**(3): p. 180-188.
8. Ohno-Machado, L., et al., *The GuideLine Interchange Format A Model for Representing Guidelines.* Journal of the American Medical Informatics Association, 1998. **5**(4): p. 357-372.
9. Afzal, M., et al. *KnowledgeButton: An evidence adaptive tool for CDSS and clinical research*. in *Innovations in Intelligent Systems and Applications (INISTA) Proceedings, 2014 IEEE International Symposium on*. 2014: IEEE.
10. Afzal, M., et al., *Knowledge-Based Query Construction Using the CDSS Knowledge Base for Efficient Evidence Retrieval.* Sensors, 2015. **15**(9): p. 21294-21314.
11. Sayers, E. and D. Wheeler, *Building customized data pipelines using the entrez programming utilities (eUtils).* 2004.