Meaningful Integration of Online Knowledge Resources with Clinical Decision Support System

Muhammad Afzal[1], Maqbool Hussain[1], Wajahat Ali Khan[1], Taqdir Ali[1], Sungyoung Lee[1], Hafiz Farooq Ahmad[2]

[1]UC Lab, Department of Computer Engineering, Kyung Hee University, South Korea.
{muhammad.afzal, maqbool.hussain, wajahat.alikhan, taqdir.ali, sylee}@oslab.khu.ac.kr
[2]SSRG Lab, School of Electrical Engineering and Computer Science, National University of Sciences and Technology, Islamabad Pakistan
{farooq.ahmad}@seecs.edu.pk

Abstract. Clinical Decision Support System (CDSS) is becoming as one of the key components of current health information systems. Contemporary CDSS system requires more attention to design and implement. The crucial aspect of KB is the richness with respect to domain knowledge which is mainly dependent on domain experts. Domain experts have understanding of the domain and wisdom to create the knowledge. However, they often seek help from online knowledge resources to find new evidences about certain disease and clinical practices. This fact is especially true for cancer disease where improvements occur more frequently. Literature has proved that online knowledge resources are capable providing answers to questions that might not be answered relying only on clinician wisdom and experience. This paper provides the technique for meaningful integration of online knowledge resources with Smart CDSS. Clinicians can get enormous benefits from this approach to fulfill the gaps in the decisions during patients' diagnosis and treatment.

Keywords: CDSS, Online Knowledge Resources, Meaningful Integration, Knowledge Manager, Knowledge Base

1 Introduction

Clinical Decision Support System (CDSS) is the key component of contemporary health information systems like EHR/EMR. The main purpose of any CDSS is to assist physicians in the clinical processes of patient care. It improves the physicians' performance which ultimately results in overall improved performance of the healthcare organization. CDSS is composed of several components including KB as the most important.

The success of any contemporary CDSS is based on KB upon which it is built [8]. The crucial aspect for KB is the richness with respect to domain knowledge which is mainly dependent on domain experts. Domain experts have lot of understanding of the domain and wisdom to create the knowledge in KB. However, they should not be limited to rely only on the knowledge existed in their heads. Rather, they should look

at the new research to find evidences handling new patient cases with respect to certain diseases or improvements in the existing clinical practices. This fact is especially true for cancer disease where improvements occur more commonly. The research papers holding this new knowledge and evidences are called practice changing papers in the clinical terminology. Finding such papers to help in clinical practices like patient diagnosis and treatment is a true problem for physicians. Additionally, the emergent nature of medical domain contributed toward difficulties in the adoption of CDSSs as highlighted in [10]. Physicians have no established mechanism to get into these new developments in the domain. They spend a lot of their precious time on searching process. If they find the information, they don't have any proper method to convert it into knowledge. This time spending results not only in degradation of oncologist performance but also affects the patient care.

Typical CDS systems are lacking in contextual integration with online knowledge resources in a meaningful way. They rather, rely on the existing knowledge in KB. Decision support systems that possess the capability of adapting new knowledge from the current research are called Evidence-Adaptive CDSS in literature. The KB of an evidence-adaptive CDSS is based on current evidence and its recommendations are routinely updated to incorporate new research findings [11]. This paper proposes a novel approach of acquiring new knowledge from the online knowledge resources to evolve the KB of Smart CDSS. Smart CDSS is a recommendation system that assists oncologists in Head and Neck (HNC) cancer patients' diagnosis and treatment [9]. The same service can be shaped towards smart home environment by providing expert guidelines to patients from approved clinician knowledge base at their home environment.

2 Background

Generally, a CDSS is an interactive computer-based information system that assists physicians and other healthcare professionals in the process of clinical decision making. Its goal is to reduce the time of physicians, spent on the clinical tasks that could otherwise be achieved through the use of CDSS. Any typical CDSS has three major components; KB, Inference Engine and User Interface [4]. Among these three components, KB is the most important and is the success determiner for any contemporary CDSS [8]. However there are several other desirable features that any contemporary CDSS should possess to satisfy the user requirements. Maintenance of the KB is one of these desirable features [4] and the same is included in [1] as one of the Ten Commandments. Sometimes a CDSS system is strong from its capabilities but due to misfit into the workflow of a system, the chance of acceptance by the physicians is low. The reasons behind this lack of success included inadequate integration of CDSS into clinical workflow and inadequate integration of CDSS with EMR [6]. Since, we are implementing this system into a real environment to link Health Management Information System (HMIS) of SKMCH&RC so we are confident to break this barrier of inadequate integration. HMIS of SKMCH&RC has very well matured patient workflows to manage cancer patients for their diagnosis

and treatments. The system lacks in integrating CDSS results to cover the time spent on tasks that would otherwise be done by the computer. From technical perspective we can use either standard based or non-standard based approach for this integration. Standard based approach is preferable over non-standard due the factor of eliminating the need for developing custom APIs with significant reduction in integration costs [3]. HL7 developed Context-Aware Knowledge Retrieval Standard (Infobutton) [5] is becoming popular and is considered for implementation by different entities around the world. There are two implementation guides provided by HL7 so far; URL based Implementation and Service Oriented based Implementation. In our approach we will prefer to use the later one. Infobutton only, however cannot satisfy the overall requirements. Our goal is not only to retrieve knowledge from the online resources and present them to the physicians in as-it-is format, rather to transform the retrieved information in a more easy to use manner. In addition, we also arrange them into a more logical format for the physicians to validate and generate knowledge rules from them.

3 Abstract System Architecture

The integration of Online Knowledge Resources is a process of connecting a health system with online resources in a way to collect meaningful information, present it to the user (oncologist in our scenario) and make it part of the KB of CDSS (Smart CDSS in our case). This function of integration has several sub-functions to perform as depicted in Figure 1. The KB of Smart CDSS is connected with Knowledge Manager through Input Request Generator which in turn connects to the list of subscribed online resources. The Output Response Formulator module of Knowledge Manager is connected to Knowledge Representation which then connected to Knowledge Verification and Knowledge Publisher. The selection and subscription of online resources is subject to authenticity and credibility. We considered the knowledge resources based on the selection of oncologist as finalized in the survey.

3.1 Knowledge Manager

Knowledge Manager is the main module of architecture and has a special role during the input request generation and output response formulation. When an input request is generated from within the workflow of a health system, it might not be in a format to be directly sent to an online resource. Other than conversion to standard format, it is required to add the clinical terminologies or adding new attributes or deleting the extra elements. Similarly, when the output information collected from the resources, again it might not be in format to be used by the physicians to extract knowledge. Knowledge Manager with Input Request Generation and Output Response Formulation components perform all these functions to enable the meaningful communication between health system and online resources.

3.2 Input Request Generator

This module performs the function to set the query parameters required to fetch relevant information from the appropriate online knowledge resource. It takes the input request with contextual information from the workflow of health system where CDSS is deployed and filter the unnecessary information. The unnecessary information is the one having no importance to be used as a query parameter when the input request runs at the resource side. At the same stage, new elements will be added if required in order to make the input more useful. Sometimes the information coming from within the workflow of health system is not enough therefore; we add more information to get into the right information. Upon the completion of data the input request is linked to an appropriate resource(s) based on the best match strategy.

3.3 Output Response Formulator

Once we have the final response, we need to transform it into a readable format. This transformation process requires deep analysis of the patterns in the information. Due to diverse nature of the information extracted from the resources, it is more appropriate to use semi-automatic approach assisting the physicians to structure the information in required format. After structuring, the response is converted into Arden Syntax [7] which is directly usable by the Smart CDSS system. Validation and verification is required before publishing the Arden Syntax rules into the KB.

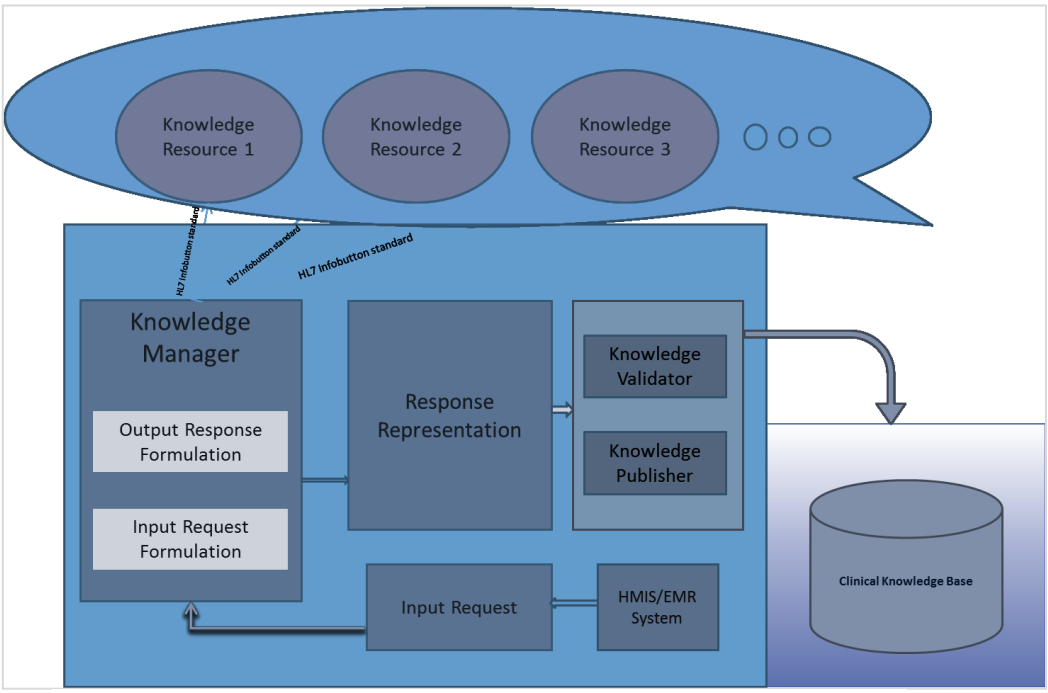

Figure 1: System Architecture

4 Methodology

We selected HNC part of the cancer disease due to the fact of physicians' feedback and support availability. We analyzed the system and realized the need for CDSS based on mutual understanding with physicians. Based on our analysis we identified that our Smart CDSS system will function at different areas like diagnosis, staging and treatments after deployment. We conducted a small survey from **10** oncologists related to HNC cancer patients' diagnosis and treatment. The survey is performed in two formats; questionnaire and interview. Results of both the methods are combined, compiled and analyzed to prove the hypothesis of our research that online knowledge resources are playing major role in the process of HNC cancer patient care. When asked; how often you visit online knowledge resources at time of HNC patient diagnosis/treatment? 80% replied with **very frequently**. The term very frequently here means that they consult the online resources on frequent bases at different times during the course of patient care. Similarly when asked; how you approach to an online knowledge resource? 60% replied with **Google** and other 40% replied with directly typing **URL**. Based on these findings, we started for the next step as how to channelize the useful online resources into Smart CDSS context. We come up with several design options like; getting into a required resource by using simple HTML request or making context aware standard approach. The selected resources and the major purpose of these resources are shown in Table 1. We divide the resources into categories as oncologists are more interested to know about the nature of the resources. In some cases they want to refer to clinical trials to study the trials occurred on experimental bases. But sometimes, they are more interested to check the results of current published research in credible journals and books. However, in few cases, they are only interested to see the ultimate guidelines if available.

We tested the links to clinicaltrials.org, PubMed and NGC by taking input from within the HNC system for selected patients and verify the results from oncologists. Although the work was at elementary level but the feedback and comments of physicians were encouraging. A lot of time has been saved for them by providing them automatic and contextual querying facility to link to a particular resource from within the system rather to type all the entries manually to get the required information.

6 Conclusion

In light of recent development in healthcare domain, advanced computerized decision support systems became the core desire for physicians to connect to the very recent research development in the domain. Smart CDSS envisioned as an evidence-adaptive CDSS to assist oncologists in diagnosis and treatments of HNC patients. By adding this capability of meaningful integration with online knowledge resources, the system is expected to remain updated with practice changing research and will provide better results as compared to the conventional CDSSs. More significantly, it is envisioned to save the physicians' time making them able to treat more patients. The integration

process of online knowledge resources has more space to improve especially in the area of accessing appropriate information and the process of transformation. Similarly, the semi-automatic process of rule generation can be made automatic to a maximum level by the use of Machine Learning techniques.

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