A Novel Knowledge Base Decision Support System Model for Breast Cancer Treatment

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Abstract

Changing trends and adoption of information and communication technology (ICT) in healthcare settings have equipped modern healthcare providers a method to resolve their day to day challenges in enhancing quality decision making and patient care. Breast cancer is one of the leading causes of death globally. The control and prevention of it is largely depends on instant access and availability of patients information and domain knowledge to the clinicians. Unavailability or delay in receiving this information leads to medical error, unnecessary complications and suffering to the patient. As an important application of Information and communication technology, Clinical Decision Support System supports the clinicians in providing easy and instant access of accurate, complete and adequate patient's information and domain knowledge for quality decision making, reducing medical errors and promoting evidence based practice. This paper focuses on the design, development and implementation of a Novel Knowledge Based Decision Support System model in breast cancer treatment for improving the accessibility of domain specific clinical data for faster and more efficient use.

Key word: Clinical decision support system, breast cancer, Information and communication technology

Introduction

Cancer is considered to be one of the ten leading cause of deaths. It is estimated that one in eight deaths worldwide occur due to cancer. It is the second leading cause of death in economically developed countries and the third in developing countries [(1)]. As per world cancer report, cancer rate could further increase by 50% amounting to 15 million new cases in the year 2020. Breast cancer is known to be one of the ten leading causes of death among women worldwide accounting for 1.3 million new cases annually. Five year survival rate from breast cancer is about 89% in United States and 76% in Europe. Survival rate in developing countries are generally lower than Europe and America [(2)].

Cancer control and prevention is an integral and challenging task. It involves sharing of and instant availability of health information and domain specific knowledge to the clinicians for quality decision making. This calls for research in providing computerised decision aids to the clinicians in improving the quality of healthcare provided for cancer patients.

Clinical Decision Support System permits explicit representation of clinical data and medical knowledge executed through a computer program and assists physicians and other health professionals with decision making tasks. It could be based on expert systems or artificial neural networks or both. It varies in design, complexity, function and applications but the basic component in all includes a dynamic medical knowledge base and an inferencing mechanism [(3)].

Knowledge base of a clinical decision support system creates a great impact on patient care where it provide domain knowledge to the clinician and support them in quality decision making during the patient encounter where interference engine execute the program by passing the command of a end user to the system.

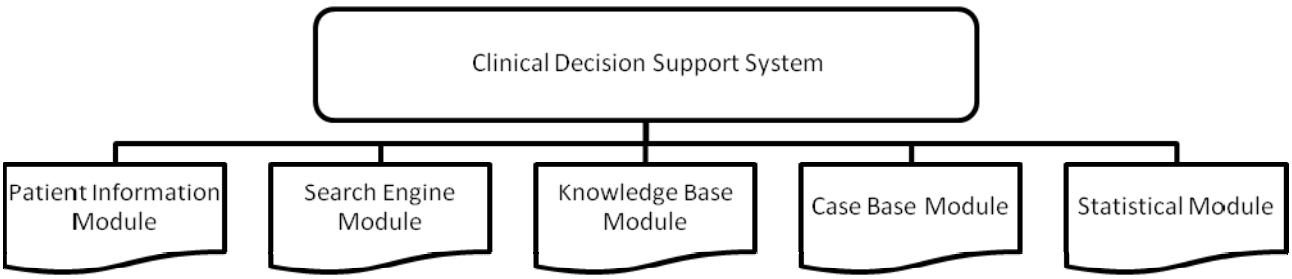
Design and Architecture of the Clinical Decision Support System

An intensive literature search has been conducted to identify the available clinical decision support systems in breast cancer care. The data collected from the literature survey showed that there are several studies that have been done in the field of clinical decision support system such as CASNET, PIP, ABEL, Leeds Abdominal Pain System, EON System[(4)], AAPHelp[(5)], Internist-I [(6)], Mycin[(7)], DxPlain[(8)], Isabel Healthcare[(9)], GDSI[(10)], PROMEDAS[(11)] etc. However, there are only a few available in the domain of breast cancer care. Works of interest in this case are Oncocin[(12)], Reterospect[(13)], Clinical decision support system based on data mining and clinical practice guidelines[(14)], Oncosifter[(15)], OncoDoc[(16)] and Computer Aided Medical Diagnosis Tool [(17)].

To identify the expectation of clinicians from the proposed system, a structured interview was conducted by the investigator. As an outcome, clinicians suggested that the system should have a user friendly customized module for recording patient information with breast cancer and allow the end users to retrieve the patient information instantly. They also pointed out that the system should have a customized search engine to allow them instant retrieval of domain knowledge and it should dynamically update knowledge. They preferred to have a feature where the system should automatically save the history of access and also provide customized statistical report of patient as and when required.

Based on the analyses of literature survey and interview, five important modules (fig.1) are being incorporated into the system to completely assist the clinicians in quality decision making. The architecture of the system is implemented using .net technology on a windows platform. The online transaction processing (OLTP) and online analytical processing (OLAP) database are created using Microsoft SQL server 2005 management system. OLTP holds the patients information and OLAP generates knowledge from the system. The front-end is designed using .net framework and Microsoft Visual Studio 2008 Application development environment.

Figure 1. Modules of Clinical Decision Support System



The details of each module are:

Patient Information Module

This customized module will assist clinician in accessing, recording and updating the events of patient care in terms of surgery, chemotherapy, radiotherapy, hormonal therapy and others rendered during their course of hospitalization and care. AJCC 6th edition cancer staging system, ICD-10 and ICD-Oncology-3rd version is also incorporated into the module to allow the clinicians in cancer staging and recording of topographical and morphological diagnosis correctly.

Search Engine Module

This module will allow the user to interact with the system through user interface for the access of offline and online knowledge of the respective domain of breast cancer. Search criteria for the instant access of domain knowledge include:

Years of evidence, where the user will have offline and online access of latest evidence available related to the breast cancer. The system will sort and display the recent evidence available as per required search.

Level of evidence, where the rules and algorithm will be generated to display the result based on meta-analysis, systematic reviews, case studies and descriptive studies.

Reviewed article, once the user search and get into the respective page displaying the domain knowledge i.e. information about breast cancer, user will have the privilege to rank the page with a scale range from average (1) to excellent (4). The scores marked by different user will be automatically calculated and average of the same will be considered. Next time when a new user interacts with the system and seek for the domain knowledge related to breast

cancer, the related URL of the article/page access and marked by other users will be created and shown. Clicking on respective URL will direct the user to respective page.

Knowledge Base Module & its Creation process

Knowledge base will support the user to keep updating the offline and online knowledge of breast cancer. The steps included in the creation of Knowledge base are:

Step 1 - This includes the gathering of domain knowledge i.e. breast cancer. The source of information looked during the preparation of model were textbooks, journals, best practice guidelines, meta-analysis, systematic review and websites.

Step 2 – This includes the authentication of gathered knowledge. The authentication was conducted with the discussion of domain experts involved in cancer care. Criteria included for the authentication was knowledge source and content.

Step 3 - This includes the creation of a knowledge warehouse for storage of authenticated domain knowledge. The warehouse contains the detailed information related to breast cancer care.

Step 4 & 5 – These include the selection of data mining tool, specification of rules/key terms and algorithm for the required search.

The knowledge base is a well organized dataset where each document has unique identity and metadata. The metadata is a file provided for each dataset in the database. The metadata furnishes extensive general and medical characteristics of the dataset. The metadata provides identification, description, content, purpose, status, accessibility, creator, publisher, data quality, condition, spatial data organization, spatial reference and attribute description, distribution and metadata reference information.

Knowledge base is the separate directory which resides in the server and documents are stored in the file format. Information can be further organized by grouping files together into logical stacks. Search folder empower users to organize files independent of their location on disk by specific set of criteria, formulated as search queries. Navigation and filter allow quick sorting and organization of files on server machine.

The system knowledge base will scan a set of document written in a natural language. It will be modelled according to the document set for predictive classification purpose and will populate the database with search index with metadata. This will also have the features to dynamically update the clinical knowledge. Creation of knowledge base uses database along with the file system. Rules and Algorithm will be generated, where the system will dynamically update the information related to breast cancer care. Only authorized users are allowed to access the database.

Case Base Module

System will allow the user to save each transaction in accessing patient information and domain knowledge. Once these are accessed, the history of transaction will automatically be stored in users profile under *C**ase Base*** module. The stored information can be retrieved and used by the user for the follow-up events as well as in provision of continuity of patient care.

Statistical Module

User specific customized queries will assist the user to perform various statistical analyses. The incidence, prevalence, mortality, survival rates of cancer cases, etc. can easily be analyzed using this module. User can also generate queries as per their requirement. The results will be displayed in the form of customized reports to assist the user in various institutional as well as third party reporting.

Functionality of the System

Any user seeking information on patients and domain knowledge has to first login to the system by entering authorized User ID and Password. Once the ID and password are passed and authenticated by the system, user will be directed to the main interface, where the user will have access to the various modules i.e. patient information, search engine, knowledge base, case base and statistical analysis.

User seeking the domain knowledge related to breast cancer has to assign the keyword/s in the search text box under the search engine module. Inference engine of the system will act as an intermediary between user and the system. It will accept and forward the request of user in terms of keyword to the system for the required search. Once system receives the command request, it will start searching the clinical knowledge based on rules/criteria specified during the designing phase of search engine. The system will first go for offline search and if the request matches with the available knowledge into the system the search result will be shown on user desktop screen.

If request does not match the available offline knowledge, the system will direct the user for online search where the list of respective URL based on rules/criteria will automatically be created and clicking on respective URL will direct the user to the page where the information related to the required search will be available.

SQL stored procedure are used to enhance the efficiency of the database access using **TSQL**. **XHTML** is used for client side scripting to make interface work dynamic and speedup the working of the system.

The search algorithm is designed using text analysis to extract the best document and list them below where the user has to click the document to view it. The term text analytics describes a set of linguistic, lexical, pattern recognition, extraction, tagging/structuring, visualization and predictive technique. The term also describes processes that apply these techniques, whether independently or in conjunction with query and analysis of fielded numerical data to retrieve best practice. These techniques and processes discover and present knowledge/fact, practices, and medications that are otherwise locked in textual form, impenetrable to automated processing.

Security Issues built during designing period

Privacy and security of patient's information is one of prime concern during the development and implementation of any I & CT application in a healthcare setup. These issues have been addressed and measures taken during the design, development and implementation of the system.

User authentication is achieved at database scope through User name and Password where the user is hidden from any of the module which he is not authorized. To guarantee health information of the patient stored during registration of the patient ***Transactions*** are implemented. This ensures atomicity, consistency and durability of records.

Form Authentication Module is implemented to gain form level authentication and to avoid unauthorized user accessing the system. Form authentication uses an authentication ticket that is created when a user logs in to a site and then it tracks the user throughout the site. However, ***ASP.NET version 2.0*** supports form authentication, which results in the ticket being passed in query strings.

SHA1 (Secure Hashing Algorithm) is implemented for secure storage of user data. It encrypts the data and sends throughout the network to prevent ***Sniffing*****.** Sniffing is observing the packets passing by a network and stealing data from a network usually in the form of password and ID name.

On generating dynamic SQL queries based on user input, an attacker could inject malicious SQL commands that can be executed by database. To avoid SQL injection attack at the database side, parameter based storage is used where each field value is passed as parameter to SQL query.

Conclusions

Cancer care and prevention is only possible through quality decision making and this can only be achieved when there is instant access and availability of patient information and domain specific knowledge to the healthcare providers. Considering quality decision making and care as one of the vital aspects, the aim of this work is to design, develop and implement a knowledge base decision support system model in breast cancer care.

The system will support the clinician in easy access of health information and domain knowledge. Dynamic updation of domain knowledge differentiates it from other existing system where it automatically updates the domain knowledge to assist the clinician in arriving at quality decision for breast cancer care. The security issues addressed and measures taken during the implementation of model will restrict the violation of privacy and confidentiality of health information.

On implementation, the system is expected to increase the clinician's efficiency by reducing their time by almost half in management of complete patient information as well as retrieval of domain knowledge as compared to the available system. Consequently, this is expected to improve the physician performance and quality of care of patient with breast cancer disease.

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