Artificial Intelligence Based Clinical Decision Support System

Introduction

In computer science artificial intelligence (AI), sometimes called machine intelligence is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals. Computer science defines AI research as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.

Today computer science has revolutionized our world and computers have become vital component of our life. It made it easy for us to analyze and diagnose the medical problems and diseases. The use of Artificial Intelligence in medicine and medical sciences are on high demand. And how they are helpful in diagnosis of diseases and pain. AI based in CDSS is to study the aspects of Clinical Decision Support Systems and to figure out the most optimal methodology that can be used in Clinical Decision Support Systems to provide the best solutions and diagnosis to medical problems. The selection of a particular methodology depends upon various parameters of problem domain. Certain methodologies are more effective in one domain while other may be even more effective in other domains. But in a wider aspect, the hybrid methodologies appeared to be more efficient and effective. AI based clinical decision support system (CDSS) is a health information technology system that is designed to provide physicians and other health professionals with clinical decision support (CDS), that is, assistance with clinical decision-making tasks. A working definition has been proposed by Robert Hayward of the Centre for Health Evidence: "Clinical decision support systems link health observations with health knowledge to influence health choices by clinicians for improved health care". CDSSs constitute a major topic in artificial intelligence in medicine.

Artificial Intelligence is an integral part of Decision Support Systems. Decision Support Systems that are implemented with the aid of Artificial Intelligence have the ability to adopt in new environment and to learn with time. Various methods are used to gather information used for the process of Decision making in Computer Aided Support Systems/ Expert Systems. These methods include Statistical Method, Neural Network, Knowledge Based Methods, Fuzzy Logic Rule Based, Genetic Algorithms etc. The selection of a particular methodology depends upon various parameters such as

What is the problem domain?

What can be the solution?

Amount of data available.

Researcher choice and purpose.

Characteristics

A clinical decision support system has been defined as an "active knowledge systems, which use two or more items of patient data to generate case-specific advice." This implies that a CDSS is simply a decision support system that is focused on using knowledge management in such a way so as to achieve clinical advice for patient care based on multiple items of patient data.

An intelligent decision support system (IDSS) is a decision support system that makes extensive use of artificial intelligence (AI) techniques. Use of AI techniques in management information systems has a long history – indeed terms such as "Knowledge-based systems" (KBS) and "intelligent systems" have been used since the early 1980s to describe components of management systems, but the term "Intelligent decision support system" is thought to originate with Clyde and Andrew Whinstone in the late 1970s. Examples of specialized intelligent decision support systems include Flexible manufacturing systems (FMS) intelligent marketing decision support systems and medical diagnosis systems.

Ideally, an intelligent decision support system should behave like a human consultant: supporting decision makers by gathering and analyzing evidence, identifying and diagnosing problems, proposing possible courses of action and evaluating such proposed actions. The aim of the AI techniques embedded in an intelligent decision support system is to enable these tasks to be performed by a computer, while emulating human capabilities as closely as possible.

Many IDSS implementations are based on expert systems, a well-established type of KBS that encode knowledge and emulate the cognitive behaviors of human experts using predicate logic rules, and have been shown to perform better than the original human experts in some circumstances. Expert systems emerged as practical applications in the 1980s based on research in artificial intelligence performed during the late 1960s and early 1970s. They typically combine knowledge of a particular application domain with an inference capability to enable the system to propose decisions or diagnoses. Accuracy and consistency can be comparable to (or even exceed) that of human experts when the decision parameters are well known (e.g. if a common disease is being diagnosed), but performance can be poor when novel or uncertain circumstances arise.

Purpose

The main purpose of modern CDSS is to assist clinicians at the point of care. This means that clinicians interact with a CDSS to help to analyze, and reach a diagnosis based on, patient data.

In the early days, CDSSs were conceived of as being used to literally make decisions for the clinician. The clinician would input the information and wait for the CDSS to output the "right" choice and the clinician would simply act on that output. However, the modern methodology of using CDSSs to assist means that the clinician interacts with the CDSS, utilizing both their own knowledge and the CDSS, to make a better analysis of the patient's data than either human or

CDSS could make on their own. Typically, a CDSS makes suggestions for the clinician to look through, and the clinician is expected to pick out useful information from the presented results and discount erroneous CDSS suggestions.

Classifications

There are two main types of CDSS:

Knowledge-based

Non-knowledge-based

As detailed below.

An example of how a clinical decision support system might be used by a clinician is a specific type of CDSS, a DDSS (diagnosis decision support systems). A DDSS requests some of the patients' data and in response, proposes a set of appropriate diagnoses. The doctor then takes the output of the DDSS and determines which diagnoses might be relevant and which are not, and if necessary orders further tests to narrow down the diagnosis.

Another example of a CDSS would be a case-based reasoning (CBR) system. A CBR system might use previous case data to help determine the appropriate amount of beams and the optimal beam angles for use in radiotherapy for brain cancer patients; medical physicists and oncologists would then review the recommended treatment plan to determine its viability.

Another important classification of a CDSS is based on the timing of its use. Doctors use these systems at point of care to help them as they are dealing with a patient, with the timing of use being either pre-diagnosis, during diagnosis, or post diagnosis. Pre-diagnosis CDSS systems are used to help the physician prepare the diagnoses. CDSS used during diagnosis help review and filter the physician's preliminary diagnostic choices to improve their final results. Post-diagnosis CDSS systems are used to mine data to derive connections between patients and their past medical history and clinical research to predict future events. It has been claimed that decision support will begin to replace clinicians in common tasks in the future.

Another approach, used by the National Health Service in England, is to use a DDSS (either, in the past, operated by the patient, or, today, by a phone operative who is not medically-trained) to triage medical conditions out of hours by suggesting a suitable next step to the patient (e.g. call an ambulance, or see a general practitioner on the next working day). The suggestion, which may be disregarded by either the patient or the phone operative if common sense or caution suggests otherwise, is based on the known information and an implicit conclusion about what the *worst-case* diagnosis is likely to be (which is not always revealed to the patient, because it might well be incorrect and is not based on a medically-trained person's opinion - it is only used for initial triage purposes).

Knowledge-based CDSS

Most CDSSs consist of three parts: the knowledge base, an inference engine, and a mechanism to communicate. The knowledge base contains the rules and associations of compiled data which most often take the form of if then rules. If this was a system for determining drug interactions, then a rule might be that IF drug X is taken and drug Y is taken then alert user. Using another interface, an advanced user could edit the knowledge base to keep it up to date with new drugs. The inference engine combines the rules from the knowledge base with the patient's data. The communication mechanism allows the system to show the results to the user as well as have input into the system.

Non-knowledge-based CDSS

CDSSs that do not use a knowledge base use a form of artificial intelligence called machine learning, which allow computers to learn from past experiences and/or find patterns in clinical data. This eliminates the need for writing rules and for expert input. However, since systems based on machine learning cannot *explain* the reasons for their conclusions (they are so-called "black boxes", because no meaningful information about how they work can be discerned by human inspection), most clinicians do not use them directly for diagnoses, for reliability and accountability reasons. Nevertheless, they can be useful as post-diagnostic systems, for suggesting patterns for clinicians to look into in more depth.

Three types of non-knowledge-based systems are support vector machines, artificial neural networks and genetic algorithms.

Artificial neural networks use nodes and weighted connections between them to analyze the patterns found in patient data to derive associations between symptoms and a diagnosis.

Genetic algorithms are based on simplified evolutionary processes using directed selection to achieve optimal CDSS results. The selection algorithms evaluate components of random sets of solutions to a problem. The solutions that come out on top are then recombined and mutated and run through the process again. This happens over and over until the proper solution is discovered. They are functionally similar to neural networks in that they are also "black boxes" that attempt to derive knowledge from patient data.

Non-knowledge-based networks often focus on a narrow list of symptoms, such as symptoms for a single disease, as opposed to the knowledge based approach which cover the diagnosis of many different diseases.

Benefits and drawbacks of a CDSS

Despite the benefits, there are also cons to implementing clinical decision support systems. The first challenge is that a CDSS must integrate with a healthcare organization's clinical workflow, which is often already complex. Some clinical decision support systems are stand-alone products that lack interoperability with reporting and EHR software. Also, the number of clinical research and medical trials being published on an ongoing basis makes it difficult to incorporate the resulting data into CDSS in a timely manner. Furthermore, incorporating large amounts of data into existing systems places significant strain on application and infrastructure maintenance.

Illustrative examples of clinical decision-support systems

To illustrate the state of the art and the ways in which new technologies have affected the evolution of decision-support tools, we shall discuss selected features of several well-known decision-support systems in two major areas: diagnosis and patient management. Quick Medical Reference (like its predecessor, Internist-1) supports diagnostic problem solving in general internal medicine, while DXplain is a continuously evolving Web-based diagnostic system. The EON system is a representative example for one of the recent guideline-based decision-support systems, which provide therapeutic recommendations for treatment in accordance with predefined protocols. The systems discussed here in some detail demonstrate widely differing architectures. Quick Medical Reference is used primarily as a standalone system, DXplain is a self-contained system, but currently accessed mostly over the World Wide Web, and EON comprises a set of software components that are designed to be integrated within larger clinical information systems.

Diagnosis: The Internist-1/QMR Project and the DXplain System We will demonstrate the task of supporting clinical diagnosis using two well-known but very different systems: Internist-1, which evolved into the QMR system, and the DXplain system, which is an important Web-based resource. The Internist-1/QMR project Internist-1 was a large diagnostic program that was developed at the University Of Pittsburgh School Of Medicine in the 1970s. The Internist-1 program subsequently grew into a decision-support system known as Quick Medical Reference (QMR).QMR was marketed commercially for several years, and was used by a large community of practitioners and students. Although currently the system is not actively supported, it has been highly influential and the subject of considerable study by the medical-informatics community.

Construction of AI based Decision-Support Tools

Despite significant research progress since the idea of computer-based medical decision support systems first emerged, several barriers continue to impede the effective implementation of such tools in clinical settings. As we implied earlier, these obstacles include unresolved questions of both science and logistics.   Artificial Intelligence is an integral part of Decision Support Systems. Decision Support Systems that are implemented with the aid of Artificial Intelligence have the ability to adopt in new environment and to learn with time. Various methods are used to gather information used for the process of Decision making in Computer Aided Support Systems/ Expert Systems. These methods include Statistical Method, Neural Network, Knowledge Based Methods, Fuzzy Logic Rule Based, Genetic Algorithms etc. The selection of a particular methodology depends upon various parameters such as For the diagnosis of pain, medical science need computer aided software that can collect the health related signals from patients and transform them in pain intensity. Pain causes degradation in the life of patients and due to lack of the proper evaluation methods, sometime patient stops asking for further medication as the pain becomes worse. Similarly the critical monitoring of the patient after operation needs accurate measurement of the medicine proportion as over dosage can sometime result into threats of life .The use of a Clinical Decision Support System to measure the intensity and diagnose the pain is much more efficient, effective and economical.

The use of the Clinical Decision Systems in surgery is also very common. Minimal invasive surgery is a preferred method for operations today. The development of a reliable flexible fiber or wave guide will enable surgeon to bring laser beam transcend oscopically within body cavities. It combines the endoscopy technique with advantageous laser interaction with tissue to create a powerful surgical to for operating procedures. It lower cost, fastest healing and minimal post-operative pain.

Description of basic algorithms and methods

Data:- Clinical data, including outcomes, treatment information, demographic information, and other clinical indicators, was obtained from the electronic health record (EHR) at Center stone for 961 patients who participated in the Client-Directed Outcome-Informed (CDOI) pilot study in 2010 , as well as patients who participated in the ongoing evaluation of CDOI post-pilot phase. This sample contained 5,807 patients, primarily consisting of major clinical depression diagnoses, with a significant number of patients (~65%) exhibiting co-occurring chronic physical disorders including hypertension, diabetes, chronic pain, and cardiovascular disease.

Framework overview: - A general framework agents encapsulate the characteristics and functions of their respective real-life counterparts – e.g. patient agents incorporate individual patient-specific data and individualized transition models while physician agents maintain beliefs about patients' health status and treatment effects and have decision-making capabilities. Where initially patient-specific MDPs are created from the transition models and physician agents must incorporate patient-specific evidence/information into existing beliefs prior to decision-making at each time point. The decision-making process then recourses down the MDP search tree, resulting finally in a determination of an optimal current action and updates to patient belief states.

The algorithm steps are as follows:

1) Create patient and physician agents

2) Create patient-specific MDP

Then, for each time point (if not horizon):

3) Calculate current outcome delta, physician agent filters evidence

4) Determine optimal current action via MDP search tree

5) Perform action and update belief states

6) If action ≠ not treat, return to step 3

POMDP decision-making environment:- We model the decision-making environment as a finite-horizon, undiscounted, sequential decision-making process in which the state from the state space consists of a patient's health status at time.

<u>Application areas in data mining where it can be applied and used</u>

Artificial intelligence based Clinical decision support system is health information application technology system where it can be used is to provide physicians and other health professionals with clinical decision support (CDS) that is assistance with clinical decision making tasks.

Intelligence based and Computerized clinical decision support system (CDSS) are electronic tools that prompt provider behaviors in various areas of patient care, including medication ordering, chronic disease management, healthcare screening , and vacation. CDSS can provide physicians, nurses, pharmacists, and other care provider with patient specific prompts or warnings, treatments, automatic medication dosing calculators, or reports of overdue testes and medications as appropriate. These tools can be integrated with comprehensive electronic health record (HER) systems , part of computerized physician order entry (CPOE) system , or a standalone electronic interface that prompt provider behaviors in various areas of patient care , including medication ordering ,chronic disease management , health care screening , and vaccination.

AI based CDSS can used to provide physicians, nurses, pharmacists, and other care providers with patient specific providers with patient specific prompts or warnings treatments, automatic medication dosing calculators, or reports of overdue testes and medications as appropriate. These tools can be integrated with comprehensive electronic health record (HER) systems , part of computerized physician order entry (CPOE) system, or standalone electronic interface; various type of CDSS exist for different workflows and settings ,including primary ,inpatient, acute, long term ,and health care.

What can be done with AI based CDSS

Our suggestion is that as we know CDSS are computer-based programs that analyze data within electronic health record to provide prompts and reminders to assist health care providers in implementing evidence-based clinical guidelines at point of care. It's the work system that Advanced CDSS continuously monitor the documentation of care in HER (electronic health record) systems while communicating with unrelated information systems, They are also typically programmed with rules informed by established clinical guidelines.

As clinicians record care steps in the EHR, the CDSS analyzes documentation entries in real-time relative to all other available patient information. When this analysis detects that an important clinical detail has been overlooked, CDSS issues an alert. When the system performs as intended, false alarms are minimal, and those that do appear can inform care decisions in a variety of important ways:

Suggesting a course correction in care based on patient history. One of CDSS's primary functions is to eliminate drug-drug interactions and track patient allergies. If a physician prescribes what is normally the best medication for a specific condition but is unaware of other medications the patient is taking, or of patient allergies to the drug in question, CDSS can suggest the most effective and safe alternative. This same principle applies to many other factors in patient history.

Detecting an unfavorable change in patient condition. Patients are constantly monitored for changes in condition while hospitalized. In many cases, time is of the essence in detecting deterioration. Consider sepsis – the presence of harmful bacteria in tissues, typically through wound infection – which is a leading cause of hospital death. CDSS systems can detect when successive lab tests and changes in patient vital signs indicate the likelihood of sepsis onset, alerting staff to intervene at the earliest possible moment. This principle can guide intervention in a number of types of deterioration.

Improving imaging safety. Alerting clinicians that an imaging order may duplicate an existing imaging study for the patient is a basic CDSS function. Advanced CDSS can further eliminate unnecessary imaging by evaluating the need for a study relative to the patient's overall condition and history, with the potential for recommending a different diagnostic test that avoids exposure to radiation.

These are just a few examples of the contribution that AI is making today to care improvements through CDSS. As CDSS become increasingly sophisticated, we can expect them to assume a still greater role in improving care outcomes and patient safety.

Conclusion

Artificial Intelligence is an integral part of Decision Support Systems. Decision Support Systems that are implemented with the aid of Artificial Intelligence have the ability to adopt in new environment and to learn with time. Various methods are used to gather information used for the process of Decision making in Computer Aided Support Systems/ Expert Systems.

AI based CDSS have the potential to improve clinical practice settings. Care should be taken when selecting and implementing such systems to achieve the goal of improved clinical practice while avoiding potential adverse impacts sometimes associated with the implementation of new technologies in complex healthcare settings.