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Just-In-Context Clinical Knowledge Dissemination with Clinical Information Assistant

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ABSTRACT

This paper introduces a concept of updating knowledge in its clinical use. Clinical Information Assistant (CIA) is a just-in-context medium of clinical knowledge dissemination. Relevant information is displayed in a very simple form in real-time in response to the conversation between a patient and a clinician. Detailed information can be viewed later. Medical knowledge is constantly updated through knowledge update providers.

Appropriate information is given in the right timing within the context. Clinicians update their related knowledge while treating patients. This helps clinicians get more medical information about the kind of patients they have. It also minimizes the detachment between knowledge and its clinical context.

1. INTRODUCTION

1.1 Problem

In spite of the enormous expenditure in the health care industry, the quality seems to suffer. The health care market is the largest industry in the United States. The expenditure is expected to reach $2.2 trillions, or 16.2% of the national GDP by 2008. [1] Up to 98,000 US residents die each year as a result of preventable medical errors according to the estimation from the U.S. Institute of Medicine. [2]

Lack of proper information systems can cost many lives as well as much money. A nationwide survey revealed that the adults in the U.S. receive only about 50% of recommended care because of the deficits in adherence to recommended processes for basic care. [3]

Furthermore, the National Academy of Sciences' Institute of Medicine estimates that the deaths caused by medical mistakes are greater than deaths caused by AIDS, breast cancer or car accidents. The number of deaths caused by medical error has been estimated to be 98,000 individuals per year. [4]

In order to offer proper medical treatments, clinicians must be informed of the breadth of knowledge that is related to the treatment of their patients. In other words, clinicians must be able to consider all existing options for treating their patients. If a particular treatment is not appropriate to be suggested in a clinic, the patient should be informed and redirected to an area specialist of that treatment option. This can happen only when clinicians have kept up with the wide spectrum of the current knowledge.

Medical information systems are essential for proper decision making because it is, in reality, not possible for a clinician to know the overflowing amount of new medical procedures, drugs, rare complications, and unproven bleeding-edge experimental treatments. Such information systems help assessments and recommendations tailored to individual patients based on the up-to-date knowledge.[5] Thus more healthcare organizations are paying attention to such decision support systems.

1.2 Previously Attempts

Many have tried to replace human intelligence with artificial intelligence (AI) of a sort. As proven in many recent attempts, medical knowledge and experiences are too complex to be transferred to a computer system using the technologies of today or the foreseeable future.

Case-Based Reasoning (CBR) is often presented as if it could solve medical information system challenges. It is useful only if wide spectrum of clinical information can be converted into well-formed case statements that CBR can be applied to. [6] Lack of the completeness, such systems turned out too unreliable to treat a human.

Ralph Engle, one of the pioneers of computer assisted diagnosis wrote: "Our experience confirms the great difficulty and even impossibility, of incorporating the complexity of the human thought into a system that can be handled by a computer. We concluded that we should stop trying to make a computer act like a diagnostician and concentrate instead on ways of making computer-generated relevant information available to physicians as they make decisions." [7]

Computer aided diagnostic systems had failed to deliver on their promise. Clinical decision support systems have evolved from a foundation based upon statistical algorithms to complex artificial neural networks. The early decision support systems, also termed medical diagnostic decision systems, were based on Bayesian statistical theory, providing crude probability diagnoses based on certain critical variables. [8]

In 1994 Berner et al published the results of a study in which four commercially available medical diagnostic systems were challenged to diagnose a series of 105 patients each of whom had been referred to a consultant and in which of whom a diagnosis had been established. [9] The programs studied included Dxplain, Iliad, Meditel and QMR. The proportion of correct diagnosis ranged from 52% to 71% and the relevant diagnoses ranged from 19% to 37%.

1.3 Purpose and Contribution

Clinical Information Assistant is designed to introduce clinicians to new knowledge as soon as the knowledge becomes available without requiring extra time. Relevant information is displayed in a very simple form in real-time in response to the conversation between a patient and a clinician.

In addition to quick delivery of knowledge, a strong association is formed between the knowledge and its context. Clinical Information Assistant makes such an association possible by introducing knowledge in real-time within its practical use.

2. CLINICAL INFORMATION ASSISTANT

Clinical Information Assistant is a clinical decision support system that updates the knowledge of clinicians while patients are being seen.

Clinical decision support is defined as "clinical knowledge and patient-related information, intelligently filtered or presented at appropriate times, to enhance patient care."[10]

Such knowledge includes new medical procedures, drugs, rare complications, and unproven bleeding-edge experimental treatments.

Clinical Information Assistant is constantly pushed with new knowledge that is collected and processed by a knowledge update providers.

Patient knowledge can be also incorporated into Clinical Information Assistant in order to better detect the medical context of a specific patient. For example, medical sensor readings and the prescription history in an electronic medical record system can help the discovery of the medical context of a patient. Better detection of the context leads to better-targeted knowledge in clinicians.

Clinical Information Assistant is a non-invasive, flexible system. It can be easily incorporated into an existing clinical environment. It is not at all required to change the workflow of a clinic in order to deploy Clinical Information Assistant.

2.1 Architecture of Clinical Information Assistant

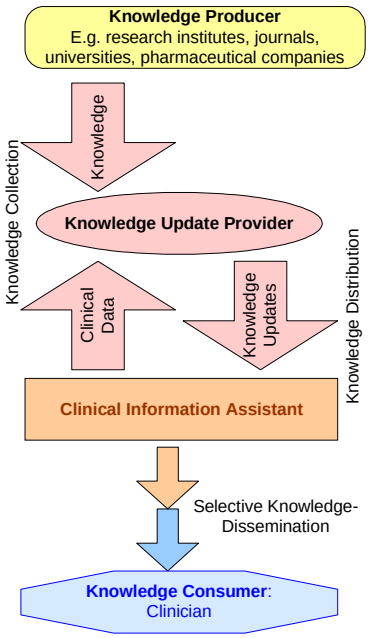
The system involves of two main entities. Knowledge update providers collect and processes information. Then the knowledge is distributed to Clinical Information Assistant. Clinical Information Assistant serves clinicians with the knowledge. (Figure 1)

2.1.1 Knowledge Collection

Knowledge Update Providers actively collect knowledge from Knowledge Producers. They collect all clinical knowledge that can help clinicians including new treatments, procedures, drug information and etc. Knowledge Producers include academic research institutes, commercial pharmaceutical companies, academic journals, and etc. (Figure 1)

Clinical data is pulled from clinics and processed into collective knowledge. For example, clinical notes can be collected anonymously and used to build preliminary clinical trial data.

Figure 1. Clinical knowledge flow



The processed knowledge is pushed back to Clinical Information Assistant to help clinicians. For example, Clinical Information Assistant can give a clinician an advanced warning when a patient with similar symptoms that had complications in other clinics.

2.1.2 Knowledge Distribution

Collected knowledge is fed into Real-Time Clinical Information Assistant. For example, new treatments, procedures or drug information can be introduced. Individual clinics can choose what kind of information is fed into their Clinical Information Assistants. (Figure 1)

2.1.3 Selective Knowledge Dissemination

Knowledge is offered to knowledge consumers, clinicians. They decide whether they skim through it, or bookmark and trace its reference. The upper arrow depicts the knowledge offer from Clinical Information Assistant. The lower arrow indicates clinicians' selection of offered knowledge whether he wants to find out more or not. (Figure 1)

2.1.4 Components of Clinical Information Assistant

Real-Time Clinical Information *Assistant* consists of two main components, Real-Time Navigational Display and On-Demand Informational Display.

2.1.4.1 Real-Time Navigational Display (RND)

The speech-recognition engine in Clinical Information Assistant feed the recognized text from the conversations in consultation sessions between clinicians and patients into the context discovery engine. Thus, Clinical Information Assistant can display appropriate content based on the context of the conversations. (Figure 2)

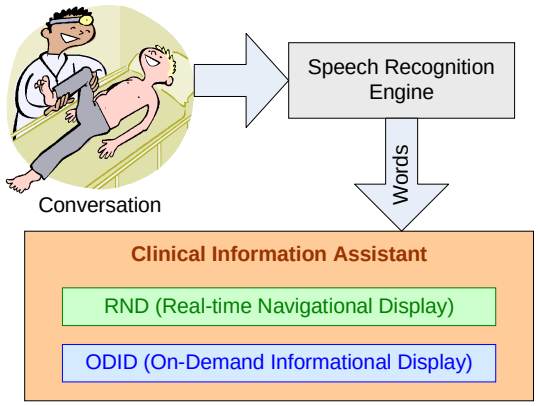
Real-Time Navigational Display (RND) gives a clinician the opportunity to update his or her knowledge on the issue of the patient being looked at. It is recommended that only a small number of items would be displayed on the screen so that the clinician can recognize them all at a blink.

2.1.4.2 Displayed Content

A consensus in the market between knowledge update providers and clinics would be the biggest determining factor of the content. In general, at least new treatments and complications should be delivered. Depending on the preference, any information can be displayed. For example, when there is a prescription, drug availability of local retail pharmacy could be useful as a convenience service to the patients.

Finally, the process model organizes actions sequentially and hierarchically in order to determine which actions are crucial to the care process and in what order the care should be delivered.

Figure 2. Architecture of clinical information assistant



2.1.4.2.1 RND Scenario

While assessing the patient's problem, the patient explains symptoms verbally to a clinician and the computer recognizes the patient's voice. The computer shows related information. Then specific stomach risk questions are automatically shown to the screen of the clinician. According to the standard procedure, the system provides the clinician check points to go over with the patient. Information is provided tailored to this specific patient and the conversation.

The patient gets educational materials on the increased risk of liver cancer in a person who takes aspirin frequently. This was done in conjunction with the clinic's electronic medical record system.

The system generates alerts regarding potentially dangerous conditions for a patient (drug allergies), or it also reminds clinicians of routine tasks such as more frequent screening for liver cancer in a patient who takes aspirin often. It may provide information tailored to the patient's needs, a list of journal articles, or simply general knowledge on their specialty.

2.1.5 Navigation

RND updates a screen whenever context changes. Context Discovery is performed by analyzing all the recognized keywords. (Figure 3) Which items are appropriates are determined by a module provided by the Knowledge Update Provider along with knowledge updates.

A new instance of Real-Time Navigational Display can be generated whenever there is a new recognized keyword. Temporal Navigation allows a clinician to go back and forth to see what was displayed before. Meanwhile the system will continuously generate new instances in response to recognized keywords. (Figure 4)

2.1.6 Selective Dissemination of Knowledge in Clinic

Knowledge is offered as a form of knowledge references (L_k) (Upper half of Figure 5) in Real-Time Navigation Display. Clinical Information Assistant offers knowledge in the detected context of a clinician-patient session. As conversation goes along, different knowledge is offered in a very concise form. Detailed information is to be displayed in On-Demand Informational Display (ODID) or bookmarked at a user request for further research later. (See Figure 5)

Thus clinicians can selectively update knowledge that is more important in their clinics. The information reference let the clinicians know the existence of such knowledge which otherwise would have been overlooked without such a system.

Figure 3. Generation of instances of real-time navigational display on context change

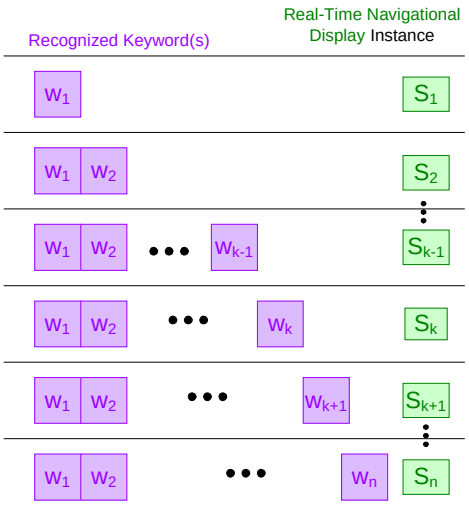


Figure 4. Temporal navigation in real-time navigational display (RND)

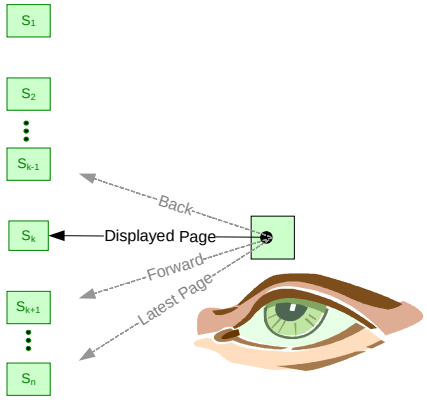
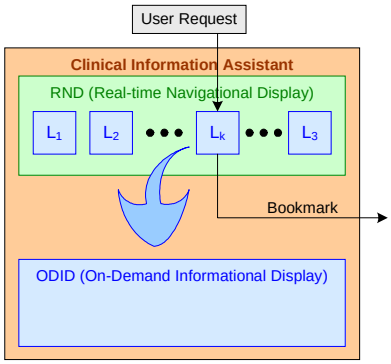


Figure 5. Knowledge references to detailed information or bookmarks



User requests can be received with any input device such as touch screens. Specific methods are to be determined by Clinical Information Assistant implementers.

2.2 Interaction with EMR (Electronic Medical Records) System

Real-Time Clinical Information Assistant is a completely independent, separate entity that interacts with an EMR System. However, Real-Time Clinical Information Assistant can use an EMR System for better context discovery. Interoperability standard needs to be in place in order to take advantage of this in a multi-vendor environment.

The electronic medical record should be considered to be integrated into Clinical Information Assistant because that information adds tremendous value to the general knowledge delivered into clinic. For example, patient history, previous encounter history, drug allergies can be also taken as simple as key words.

2.2.1 EMR Integration Scenarios

When the patient arrives for an appointment, he is asked to provide information on treatment preferences as well his health status. The patient answers a computer-based questionnaire that enters data directly into the electronic medical health record. Clinical Information Assistant remind the clinician of issues that may have caused the patient's stomach problems. For example, the patient might have taken aspirin from time to time to kill some pain and has a previous diagnosis of liver problem. It might indicate that attention should be given to cancer screening and this patient may need special treatment.

2.3 Economic Flow

Clinical Information Assistant is designed to save clinicians time and increase the quality of service by updating their knowledge as soon as it is available. Knowledge is introduced in session without spending extra time. This would provide incentive clinicians to purchase Real-Time Clinical Information Assistant.

If Knowledge Update Providers can collect more clinical data from individual clinics, better context discover is very likely. Knowledge Update Providers can encourage by paying the clinic or subsidizing some of the cost of deploying Real-Time Clinical Information Assistant.

Medical retailers can provide inventory to provide availability information to Knowledge Update Providers. Depending on the setting, clinics can provide their patients with the inventory information of prescriptions or medical equipment.

2.4 Benefits

Clinical Information Assistant can help lowering health care cost by lowering the chance of medical lawsuits. Fewer medical lawsuits can lower the insurance premium for clinics, which leads to the overall cost cut. The liability can be even avoided when patients are informed of the options to test for it thoroughly, or all the risks involved in a treatment when preceded without thorough test.

In other words, less risk will be taken without having appropriate information. When there is a risk involve in a treatment, both the patient and clinician would understand it before proceeding.

A certain level of quality standard can be set. Clinical Information Assistant can reduce the variation of practice patterns by providing standard treatment information through the system. This way, patients in all participating clinics can expect better quality assurance regardless of the clinic they are in.

More lives are expected to be saved with Clinical Information Assistant by providing a reinforced medical treatment standard.

Better-targeted, specialized knowledge update is possible. Clinical Information Assistant makes this possible by delivering information just in context. Clinicians would get more information that is related to his patients than other generic information because related information would be fed while clinicians treating their patients.

More time can be allocated to caring a patient than to memorizing simple but large amount information. For example, a drug-drug interaction matrix can be quite large. Clinical Information System can easily provide such information and free clinicians for better patient care.

Clinical Information Assistant reduces disparity between clinician knowledge. Therefore more current knowledge would be disseminated as soon as it becomes available.

The same way, the system will improve prescribing practices, reduce serious medication errors, enhance the delivery of preventive care services, and improve adherence to recommended care standards.

Finally, all of the above improvements are provided within a clinician's consultation session without spending much extra time. The voice-activated RND (real-time navigation display) facilitates this time-saving information delivery.

3. CONCLUSION

The system will allow maintenance of a standard practice pattern, which includes the provision of care based on specified care paths and/or flow sheets. Furthermore, the treatments and protocols chosen for care provision can be compared to an industry standard, or a "best practice" methodology.

Clinical Information Assistance system will increase the standardization of care, reduction of practice pattern variation, successful and effective diagnosis, and correct care path choice in the clinical decision support domain of the medical information system. Our clinical decision support system will offer the possibility to improve the quality and reduce the cost of care by influencing medical decisions at the time and place that these decisions are made.

The trend for the future shows increased dependence on clinical decision support systems by clinicians. Constant contact with such systems will ensure that the most optimal level of care is provided utilizing both clinician judgment and technological innovativeness. Such a future will mean that clinicians and other health care providers will have to change the way they collect, sort, and use health care data. The issue that decision support systems are only a tool for advice and not a computer making the final decision has increased clinicians' comfort level with decision support systems

Through the satisfaction of aggregate clinician needs in conjunction with the needs of quality health care demands, the implementation of real-time clinical assistant using the voice recognition technology in a medical information system can be advantageous to the health care delivery process. This can be achieved as a part of practice itself as opposed to extra time spent outside clinic.

A clinical decision support system is only as effective as its underlying knowledge base. In order for Clinical Information Assistant to be effectively in use, some investment must be made on knowledge update providers before clinics can consider using Clinical Information Assistant.

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