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Improving Clinical Care with MIDGI-A

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Abstract

Physicians are faced with ever increasing quantities of information. Providing easy access to relevant medical information will improve the quality of care received by patients. Current medical agent programs serve as either expert systems or simple search engines. This article proposes a new agent-based methodology for improving medical information retrieval via the world-wide-web.

Introduction

Physicians are faced with an ever increasing amount of information as new techniques and equipment are developed. More than 360,000 new articles are published in the medical literature each year (Detmer and Shortliffe, 1997). With the advent of web publishing and the corresponding increase in information availability, physicians simply cannot process all desirable information (Silverman, 1998)).

New protocols and techniques can significantly improve the accuracy of diagnosis and the quality of care delivered to patients, if physicians are aware of the latest findings. However, diffusion of new medical knowledge to clinicians is typically very slow (Detmer and Shortliffe, 1997). Automating decision support and improving access to information are two performance challenges for information systems research in medical domains (Altman, 1999).

Intelligent agents provide the method for addressing these information systems shortcomings in medical applications. Current research on intelligent agent applications is centered around four areas: basic search engines, telecommunications systems, e-commerce, personal assistants (see Jennings and Wooldridge, 1998; Brenner et al., 1998). While some limited applications of agent technology have been made in medical domains, they focus on providing user-friendly interfaces to basic search engines (Baujard et al., 1998) or expert system-like decision support with local information in specific medical areas (Della Mea et al., 1999). Furthermore, these agent applications are typically used only in university settings or perhaps at a specific hospital and have not made it into widespread use.

This paper describes the on-going implementation of an agent-based system MIDGI-A (Medical Information and Diagnosis Guidelines Internet-Agent) that will automatically alert physicians to new and reliable information that is related to cases they are currently working on.

2. Practical Considerations and Solutions

New medical information including new treatment and diagnosis protocols, is generated at an ever-increasing rate (Detmer and Shortliffe, 1997). Intelligent agents offer a potential solution for managing this deluge of information, but face several constraints for application in medical domains. Among these constraints are:

- Information quantity and quality/accuracy(Silverman, 1998),
- Confidentiality,
- Scope (global versus local) (Chueh and Barnett, 1997),
- Terminology (Chute et al., 1998).

Most of this new medical information is available via the internet and world-wide-web. Unfortunately, there are no barriers to entry for publication purposes on the web and information located on the web must be evaluated for authority as well as applicability, which is a short-coming of current search engines (Ackerman and Hartmann, 1998). Simply finding information on the web is no guarantee of its correctness.

MIDGI-A is an agent-based system that performs information gathering and screening for physicians. The MIDGI-A system uses an embedded hierarchy of web sites that have been deemed reliable, such as the New England Journal of Medicine at www.nejm.org or the medline database of medical articles, to attempt to overcome the reliability issue of web-based information. The physician user may at any time modify the web site reliability hierarchy by adding in new sites or deleting questionable sites that were placed into the hierarchy. The MIDGI-A agents will also follow links to web sites that are contained on pages published at reliable sites. Information gathered from sites that are links from reliable sites are conditionally reported to the physician user. An abstract of the linked information and a notification that this information is obtained from a site outside of the current hierarchy is reported to the physician user, who can then request the full article.

Periodically MIDGI-A performs a meta-search, similar to current "dumb" search engines, to identify emerging web sites that contain medically relevant material. Newly identified sites are given a preliminary evaluation index based on several factors including: location of the site, does it appear to be a new journal, is it an individual or organizational or commercial site, etcetera. Finally, with the MIDGI-A preliminary evaluation, the site is presented to the physician for final approval. Those sites that have been previously visited by an agent and rejected by the physician user are automatically withheld from further

consideration. The use of the limited list of reliable medical information web sites serves to increase the speed of MIDGI-A agent searches for new information by limiting the number of sites that must be visited and consequently also helps to reduce the information overload produced by the quantity of new information published on the web. Additionally, the periodic meta-searches help to insure that new high quality sites are eventually considered and included in the set of reliable medical knowledge web-resources.

The use of intelligent agents helps to ensure patient confidentiality. Each agent extracts search priority key-words from the electronic patient record (or as specified from a physician query) and uses these for locating relevant web-based information, without using any patient identifiers. Knowledge of the correspondence between an agent and particular patients is maintained by a coordination agent that is housed locally.

Terminology is a particular concern in the medical domains since no universal standard exists. Several encoding schemas are currently used such as the ICD-9-CM or UMLS. The MIDGI-A system utilizes a thesaurus which maps terms from different terminology systems. Multiple agents are created to cover the spectrum of currently identified medical terminology systems covered by MIDGI-A.

Another consideration is the acceptance of new technology by physicians. Typically, if a new information systems technology requires a change in the standard operating procedures of a physician it will not be accepted. Details of implementation and how MIDGI-A attempts to integrate into existing methodology are discussed in the next section.

3. Implementation

The MIDGI-A agent-based system is a part of a larger electronic health maintenance system (EHMS). The agents generated by MIDGI-A serve multiple purposes, all aimed at improving the quality of care delivered to patients. MIDGI-A requires a computer system (and integrated with the internet/world wide web for use of the protocol gathering agents) to be present in the physician's office. It is assumed that the patient calendar is maintained on the system. MIDGI-A agents work as a federation of agents as shown in the Figure.

The federation of agents, described in detail in the remainder of this section, enables MIDGI-A to accomplish multiple tasks that impact the quality of care received by patients. Furthermore, the federation permits multiple independent web-based searches to occur simultaneously, while limiting information overload and information redundancy through the coordination agent.

The first application of agent-technology, which has already been seen in personal assistants, is to generate agents that will remind the physician or office administrator regarding upcoming patient visits and when laboratory results become available (Silverman et al., 1998). These reminder agents are automatically generated by MIDGI-A whenever a new patient appointment is entered into the scheduling system.

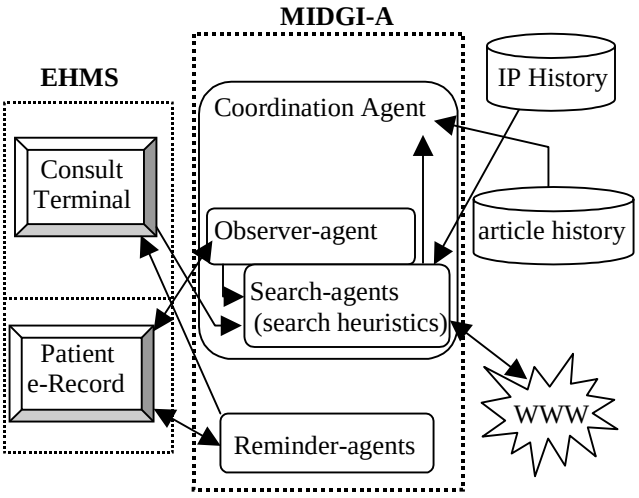
MIDGI-A's internet search agents become available upon request by the physician to locate information regarding a patient's diagnosis, new symptoms, or treatment plan. This will work similar to the physician consulting medical reference texts, but will be performed electronically. Again, since the number of sites visited by the agents is limited by the reliability hierarchy, the search for information on conditions, symptoms, and protocols occurs very quickly.

Current research is investigating the augmentation of MIDGI-A search agent evaluation functions to determine when information is new and corresponds to the current patient's condition(s). Part of this evaluation mechanism is achieved by cross referencing terms for diagnosis and treatment against known signs and symptoms currently recorded for the patient.

The ideal situation is for a physician's office or hospital to maintain patient records electronically. When electronic patient records are available, such as the CRSP system in use at VA hospitals, the MIDGI-A knowledge search agents may be activated automatically as well as intentionally by the physician. MIDGI-A uses an observer agent for the medical record database. Whenever an update to a patient record is made, including the creation of a new patient record, the MIDGI-A observer agent will spawn a collection of search agents that will search for new knowledge concerning new symptoms, diagnosis, and/or treatments that are recorded in the patient's electronic record. Agent acquired knowledge can be made available in two different ways: as a notification, similar to the reminder agent's described above, whenever the corresponding patient's electronic record is opened or as an electronic attachment to the patient's record. The electronic attachment method will be made into a specific area of the patient record specified by the physician.

Since many patients may suffer from similar symptoms and diagnosed illnesses, future work with MIDGI-A will investigate the establishment of coordination agents for specific classes of morbidity. The purpose of the coordinator agents would be to recognize when multiple agents (each for a different patient or specific physician query) are being launched to search for similar or highly correlated information (i.e., same disease or set of symptoms) and then to only permit one of the agents (or a subset thereof) to proceed with the intelligent search. Once the single agent returns with its information, this information would then be shared with the other paused agents that desire the same information, thus reducing system overhead. Additionally, the coordination agents are responsible for validating the agent information returns against a database of previously retrieved articles, to eliminate data redundancy.

Figure: MIDGI-A federated architecture.



Implementation of the MIDGI-A system is currently planned for installation at a single VA hospital. Initial testing which will target measurement of the usefulness of the knowledge returned by MIDGI-A search agents and whether or not the new knowledge affects a physician's decision on diagnosis or treatment of a patient. Testing will be performed by asking physicians that work at the VA to respond to questionnaires and through patient record examination. Following the initial testing, if an acceptable level of utility is achieved, the MIDGI-A system will be extended to all VA hospitals in the United States. Fortunately, the VA system is connected via an intranet, does have electronic patient records, and maintains secure connections to the internet and world wide web.

4. Conclusions

Physicians desire the most up-to-date information available on treatment protocols, however the world wide web and electronic journals provide daunting quantities of information to utilize. Additionally, not all of the information that is available on the web is accurate or reliable. Intelligent agents offer an ideal solution for knowledge management in medical domains.

The MIDGI-A agent-based system attempts to overcome some these significant problems with search engines by limiting the domain scope of the search and providing built-in evaluation of the relevance and reliability of web information. Continued development of the MIDGI-A system is hoped to provide a flexible tool to physicians for managing the ever increasing quantity of medical knowledge that is available electronically.

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