The New Telemedicine Paradigm: Using Internet-Based Multimedia Electronic Medical Record Systems To Support Wide-Area Clinical Care Delivery

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Many current electronic medical record systems (EMRSs) are designed primarily to handle text-based data and thus cannot accommodate the increasingly important imaging components of the patient record. This is especially the case in oncology, which is particularly dependent on imaging data for the diagnosis, treatment, and followup of a wide variety of cancers. The next generation of EMRSs will support the integration of important textual, numeric, imaging, and signal-based medical data. These new multimedia EMRSs[1] require novel database models, data compression technologies, and user interfaces. Many of these technology requirements can be addressed using emerging Internet standards developed to support the security, compression, and multimedia needs of nonmedical applications. The resulting secure, Internet-based, multimedia medical record has exciting potential to address a core need of telemedicine—delivering interactive clinical data and decision support tools over a wide geographical area.

Since 1993, with funding from the National Library of Medicine, we have been developing such a system. The current architecture, called Chart Engine, provides a complete, Internet-based, multimedia medical record for all patients managed at the University of Pittsburgh Cancer Institute (UPCI), which provides cancer care to a large patient catchment area that includes western Pennsylvania, eastern Ohio, and northern West Virginia. Supporting more than 40,000 patient visits per year, the UPCI network delivers care in large urban medical centers, small suburban hospitals, and rural clinics. In many ways, it is a perfect testbed for studying the informatics issues that arise during the development, deployment, and evaluation of an Internet-based clinical information system that must support an image-intensive medical domain.

The Chart Engine client is written in the Java programming language and runs within Microsoft Corporation's Internet Explorer Web-browsing application on the Windows NT platform.

The system provides real-time access to the following information:

- All clinical documents and laboratory test results stored in the University of Pittsburgh Medical Center (UPMC) Medical Archival and Reporting System[2]
- All radiology studies performed on UPCI patients at UPMC, including radiographs, computerized tomography scans, and magnetic resonance studies
- A selection of decision-support resources, including MEDLINE, a drug database, medical textbooks, and Internet-based resources such as the National Cancer Institute's CancerNet system

Chart Engine uses the Internet standard Secure Sockets Layer technology to implement the encryption and authentication of all data, including imaging data, transmitted between its clients and servers. In addition, all imaging data are automatically compressed using the ISO JPEG image compression standard. Image compression is quite conservative, on average approximately
10 to 1. As others have found[3], this level of JPEG compression has essentially no

impact on the clinical utility of the compressed imaging data in a variety of clinical settings.

Using Chart Engine, UPCI is moving toward a filmless radiology model. In such an image-dependent clinical domain, considerable care must be taken to ensure that this change will not adversely affect patient care. To elucidate the problems that might occur if and when UPCI goes filmless, soon we will begin a study called "filmless radiology with a safety net" at the main UPCI outpatient clinic. In this experiment, radiology film folders will continue to be delivered to the clinic but will be held in "escrow" while oncologists attempt to use only Chart Engine to retrieve and review radiology imaging studies. The intent is to extensively "pre-flight" filmless radiology without negatively affecting patient care or clinic efficiency.

Systems that attempt to integrate clinical information in real time confront a variety of technical, political, and social issues. Technically, designers are confronted with problems such as executing queries across databases with radically differing schemas and representational models, automated retrieval and compression of imaging data from PACS, merging patient data from external repositories that use different patient identifiers, and guaranteeing acceptable retrieval latency across multiple systems. Politically, integration may be threatening to those who traditionally have provided sole access to the data components that one hopes to merge into a single interface. This is particularly the case with imaging data, where end-user access to images involves a new paradigm that may be perceived as challenging existing roles in terms of both image interpretation and distribution. Socially, integrated clinical information systems place a particular burden on the end-user clinician who eventually may have mastered the use of a number of separate systems to obtain the information needed to support patient care.

As mentioned earlier, new database models are required to effectively manage the storage and retrieval of imaging data. Representing image content is a particular case in point. True image-based retrieval is still in its infancy[4], so instead one must look to lexical and semantic retrieval using imaging reports as proxies of the imaging data itself. The automated extraction of semantic data from radiology reports[5] can be particularly effective in this regard.

What is the relevance of Internet-based multimedia EMRSs to the field of telemedicine? If one's point of departure is to define this endeavor as being concerned with the provision of medical care at a distance, then clearly the ability to deliver clinical data, including imaging studies, to any location where an Internet connection can be established is a major advantage. It is probable that, with the advent of high-bandwidth, wireless Internet connections, many of the tasks traditionally defined as telemedicine will become standard features of wide-area multimedia EMRSs[6]. Indeed, one might posit that the term "telemedicine" will become redundant as all wide-area multimedia clinical information systems become telemedicine systems.

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