Support of Clinician Image-Related Workflow by a User-Edited, Web-Based Patient List Manager

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Clinician efficiency can be enhanced by worklists that compile useful data for rapid access at the time of need. The authors report development of a web-based, user-edited "Patient List Manager" for the Clinical Image Management System (CIMS). The CIMS List Manager interfaces with the CIMS Archive to provide the user with available studies. It has tools that let the user build personal lists from the available studies. Listed studies are moved from the archive to the cache for rapid access at the time of need. Users can build/edit the list through a browser (without viewing pictures) or from within the image viewer. In this way, the List Manager distributes list building into knowledgeable hands. This is particularly valuable at the current time when health system patient registries are not mature enough to reliably support building build anticipatory patient lists.

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ONE GOAL OF electronic medical record (EMR) systems is to provide access to patient information at the point of care. The image component of the EMR offers substantial challenges in this regard. Network bandwidth is often inadequate such that efficient delivery of images requires special "prefetching" of anticipated studies to a cache close to the site of care. In addition, clinician care patterns are complex such that the need for images cannot always be reliably predicted, precluding efficient automation of the process.

This group conducted a detailed audit of an image-intensive Neurosurgical Oncology Service utilization of electronic medical images on the Clinical Image Management System (CIMS) developed at the University of Alabama, Birmingham

(UAB). It was found that 50% of image queries were for historical studies. When CIMS user sessions (individual log-ins as opposed to individual queries) were analyzed, it was found that 32% of the time a current and historical study was retrieved, but that 31% of the time, only a historical study was retrieved. Thirty percent (30%) of the queries were for studies in the archive, requiring a 3-minute wait for a move into the cache (called the active patient repository [APIR], Fig 1). Users did not like waiting for archive retrieval and many requested that patient lists be available to support their workflow.

Several solutions for this problem were considered. Expanding the CIMS APIR from 300 GB (6 to 8 weeks of data) to hold more studies was too expensive. Rule-based prefetching seemed attractive, but several factors precluded it as an effective solution: image studies were not adequately tagged for a rule-based routing scheme that would satisfy clinician workflow (attending physician, patient location, etc), the Health System patient registries (admissions, discharge, transfer [ADT], hospital information system [HIS]) were not mature enough for reliable interface with CIMS for cache controlling, the services in question (Clinical Neurological services) see 10% of patients on an ad hoc basis (emergency room, phone calls, random consults) such that anticipatory fetching would be difficult to automate. A final issue was that we did not want to use human resources to manually route images to different locations in an electronic duplication of the old film delivery process.

The authors concluded that adequate automated image routing was not currently possible and that the most reliable source of a clinician's patient list is the clinician and staff (office, nurse, etc). Therefore, we developed a patient list manager that could be accessed and edited by the clinician and staff and interfaced with CIMS to keep listed studies in the cache (APIR, Fig 1) and readily viewable.

MATERIAL AND METHODS

Speciation of Patient List Manager

The following specifications for the list manager were generated in consultation with CIMS users:

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B.L.G. has a financial interest in Emageon, Inc, which has licensed a portion of the CIMS software from UAB and provides the CIMS DICOM Archive Manager.

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Fig 1. The CIMS Architecture supports the use of the web-based list editor. The list manager communicates with the CORBA services for access to the DICOM archive. Listed studies not in the cache (APIR) are automatically moved there, from where they are immediately available to the viewer (arrow 3). In this manner, the list manager keeps all relevant studies cached and ready for immediate viewing. The list manager is available to the user within the CIMS viewer or independently on an internet browser.

1. Each user will be able to have his/her own patient list tagged to their CIMS user name. The service supports selection of patients and specific studies, and automatically updates by adding the latest study to the list at the user's request.
2. Each list is accessible only by the user and anyone designated to share it (eg, secretary, nurse, etc). The designated sharer can edit the list, but not view the images unless authorized to do so.
3. Generic lists can be developed for multiple users to support patient groups serviced by several clinicians: Intensive Care Unit (ICU), Operating Rooms, floor wards, etc.
4. The list builder is accessible via a web browser, giving the user access to the list from anywhere on the intranet or internet.
5. The list builder is available within the CIMS viewer for editing and/or retrieval of images.
6. CIMS will move any listed study into the cache (APIR) for rapid access via the CIMS viewer.

Implementation of the List Manager

The CIMS patient list manager was developed to meet the specifications above. It is standard Java, running as an application or applet. The user logs into the list manager by specifying his/her user name, which becomes the name of the list. The user then enters the name of the patient into the list developer. The list manager queries the CIMS Digital Imaging and Communications in Medicine (DICOM) archive for the patient and returns a listing of all available studies. The user then selects the desired studies for inclusion in the list (Fig 2). Any study not in

the cache (APIR) is automatically moved from the archive into the cache by the CIMS common object request broker architecture (CORBA) service (Fig 1). If the patient is not found in the archive (future patient), the list will accept the name and query the archive later. In this manner, the clinician (or nurse, secretary, etc) can build a list for available and future patient studies. These lists are stored in a file associated with CIMS user specifications.

Within the CIMS viewer, the user selects the patient list manager from the "Study Menu" (Fig 3). The list of patients and/or studies appears. At this point, the user can select a study (or studies) for viewing, add a patient to the list or automatically update the list (update button). The update feature adds to the list any patient study performed since the last use of the list. For example, if a patient had been listed in anticipation of a clinic visit one week prior to clinic, but the study was performed the morning of clinic, it would be updated into the list.

The list manager will automatically delete a study from the list if not accessed for a preset period of time. This prevents the lists from becoming large and obsolete. CIMS logs list generation and editing events in support of utilization analysis for more efficient system engineering.

OBSERVATIONS

At present, the list manager is being used in a limited fashion by members of the Brain Tumor Treatment Program of the Clinical Neurological services with anticipation of broadening the service after this testing phase. In the absence of rigorous testing, the following observations are relevant. The list manager is an effective tool for developing patient lists that accurately adhere to specific clinician workflow. It is often more effective for the nurse or secretary to generate the list than the clinician. As with other tasks related to workflow, clinicians often rely on their support personnel to keep the lists current because they are very knowledgeable about the service, and thus can effectively generate the list. This "distributed rout-

Fig 2. The worklist has two modes of operation: Patient and Study. Under Patient mode, the user can add and delete patients. In Study mode, the user can add and delete specific studies.

Fig 3. The worklist manager is a menu option within the CIMS viewer as demonstrated in this figure. The user can edit the list or select studies for viewing. Here, the user has selected a study. CIMS displays representative thumbnails of the study in the "patient frame." The user selects the series by clicking the appropriate thumbnail. The series is then loaded into the viewer from the cache (APIR). The list manager assures that all relevant studies are available in the APIR.

ing scheme" is significantly different from a centralized rule-based image router that relies on incomplete rules to anticipate image needs.

CONCLUSION AND DISCUSSION

The goal of the CIMS Patient List manager is to provide users with a tool to develop worklists to preclude manual query of every patient and to reduce ad hoc archive queries. Our observation is that the list manager effectively distributes list generation into the hands of those who know the contents: physicians and staff. Its web-based architecture makes it ubiquitously available for use, not requiring that personnel be at a certain place at a certain time. We have found this to be a very acceptable solution at a time when image storage and delivery is sufficient, but interfaces with hospital registries are not yet robust.

Several features of give it power beyond its rudimentary design and provide a good foundation for making it more sophisticated. Browser-based access makes it available anywhere and anytime by personnel not necessarily authorized to see the images. The capability for designating shared users and generating generic lists enables users to delegate list generation to office staff and to develop lists for shared groups of patients (wards, ICUs, etc).

Another goal of the list manager is to reduce the user-based ad hoc archive queries. Provided lists are groomed to fit the clinical needs, the number of such archive queries should dramatically reduce. Due to the inevitable random patient encounter, the need for a real-time responsive archive cannot be entirely mitigated.

While the list generator was envisioned as an interim solution to await development of efficient centrally controlled list generators, there will always be a need for some user control of list generation. There is no reason this list generator cannot receive input from central Health System registries as well as the user, making it a more powerful efficiency enhancer. In addition, the logging features create a detailed listing of utilization, an audit of which can illuminate user patterns and provide specifications for future system solutions.

In conclusion, the CIMS List Manager effectively distributes list management into the user domain. In addition, there is no reason why the service cannot effectively communicate with Health System patient registries when the time comes. Because of its standard architecture, its potential for growth and integration with other data domains (labs, etc) is substantial.