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Design of the next Generation of Teleradiology

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INTRODUCTION

The German Cancer Research Center and the Steinbeis Transfer Center for Medical Informatics in Heidelberg, Germany, cooperatively developed the teleradiology system MEDICUS-2. This project was running from mid 1994 until mid 1996 [1]. The System is in use since 1/96 in 13 medical institutions. More than 50 thousand images have been processed with MEDICUS in the last twelve month. The experience gained from the MEDICUS system [2] is the basis for a *second generation teleradiology system CHILI* which is again a joint development of the Steinbeis Transfer Center for Medical Informatics and the German Cancer Research Center in Heidelberg. This paper describes the new design of the second generation system which is a completely new development.

THE NEW DESIGN

DICOM Orientation

We learned from the MEDICUS accounting data, that the system was used as a viewing station without any teleradiology function in 50% of the cases. Thus, we decided to start with a *radiological viewing station* which is completely integrated into the radiology department. As a consequence the system has to be *DICOM-oriented* wherever possible [2]. We designed DICOM interfaces for the system for different purposes. Images can be exchanged with digital modalities or other viewing stations as C-Store User and Provider. The *internal data model* of CHILI is based on the DICOM data model which had to be extended to be able to handle the necessary data for teleradiology. Images can also be retrieved from *PACS archives* or other workstations via Query/Retrieve functions. It is possible to *print* images on PostScript laser printers in the local network or an DICOM compliant laser imagers. The system itself can also be queried by other systems. Images for

teleconferences can either be transmitted using the DICOM C-Store function (as user) or via our own protocol which includes all aspects of data security (authentication, data integrity, privacy).

Fig. 1 - The user interface of CHILI

Viewing Functionality

The *ergonomic user interface* is based on the results in human computer interface research. The interface supports both inexperienced beginners and skilled experts who use the system in daily routine. The system is capable to display small-matrix images (CT, MRI, PET, ultrasound, nuclear medicine, digital fluorography) and large-matrix images (e.g. digitized radiographic films or computed radiography). Advanced review/viewing functionality including image analysis and annotations with graphics, text and sound are available. Basic image manipu-

lation functions are: interactive level/window functions, magnification, inversion of gray values, image rotation and flipping, and linear measurements. Series of 2D images can also be displayed as cine sequences. Images can also be imported to the system through a video capture interface.

Patient Database

The database is based on the SQL standard. ODBC data bases are supported as well. Several databases which might be located on different hosts can be used simultaneously. The user can query images from PACS archives through the same database interface as for local databases. The order of the data fields on the screen and the sorting order of the data are customizable by the user.

Image Transmission and Teleconference

Images can be transmitted off-line and on-line to another location. Data and functions are synchronized by the system during teleconferences. Both communication partners see the mouse pointer of the other side during the teleconference. Both partners can speak to each other via digital voice transmission of the CHILI software or an ISDN telephone which is easier to handle for many users.

Extensibility via Plug-in Mechanism

The *plug-in mechanism* is a very important feature of the new design. It is a well documented interface where end users can extend the system by own image analysis tools. Plug-ins have access to the database and all other functions and features of the system. Thus, developers can concentrate on new image analysis methods. The new modules can immediately be used in a routine environment. End users can use their existing CHILI system to run new image analysis methods instead of buying again another workstation for a new function. Several image processing research groups are using CHILI and the plug-in mechanism as a basis for new image analysis tools, like virtual surgery. It could be shown that interfaces to the RIS can also be build as plug-ins.

System Architecture

The *system architecture* is very flexible. The system is platform independent of the Unix dialect and runs also on personal computers under Linux or Microsoft® Windows NT®. The preferred platform is the Silicon Graphics Workstation O2 which has the power of a Unix workstation and a reasonable price similar to high end personal computers.

About 20 system modules can be bundled to packages, such as a *video teleradiology system* without connections to modalities, a *DICOM viewing station* (without teleradiology functions) or as *complete teleradiology workstation* with interfaces to digital modalities, printers and archives.

Client/server solutions can be build in the local network of a hospital where a powerful server is connected to the modalities, archives and other workstations while several "viewers" without databases but with teleconference capabilities can be distributed for example in the hospital wards or intensive care units. It is very attractive to run those viewers on existing personal computers under Windows-NT®. The treating physicians can view the existing images of their patients and the radiologists can discuss the diagnosis and further treatment in interdisciplinary teleconferences.

RESULTS

As a result of the new design, the CHILI system is now more a general purpose viewing station with additional teleconference features. It can be used to improve the information flow in the local department or hospital as well as the communication with general practitioners, other hospitals, or competence centers. The plug-in mechanism allows the users to extend the functionality from a general purpose viewer to an advanced image analysis workstations without the need to buy another workstation with new programs and concepts.

CONCLUSION

The result of the new design is a general radiology workstation, extensible for the future and not dedicated to *tele*radiology.

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