Collaborative Work with Medical Images in a University Hospital Environment: Three Pilot Projects

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Abstract

Medical care and research are highly specialised and distributed. Computer supported collaboration using local and wide area networks can essentially help to bridge the communication gaps between the various actors in health care and medical research. Hereby the full integration of medical image data plays a key role due to the fact that most decisions are made looking at images, e. g. an X-ray, an MRI, a photographic picture, an ECG curve and so on. In this paper three running pilot projects are presented which implement and evaluate different kinds of computer supported collaboration at a university hospital with emphasis on medical images: (1) A medical informatics research and development collaboration in endoscopy between image analysis experts and clinicians at different institutions. (2) A patient treatment collaboration between the physician at the nuclear reactor performing the radiation and the radiation planning experts at the Clinic of Radiation Therapy. (3) A medical research collaboration for acquisition of a second expert opinion during a clinical study in order to improve the quality of the study. - The acceptance of these applications by the doctors in their research and clinical work is quite good. Their improvement requirements are objectives to already defined further projects.

I. Introduction

In recent years the chances of facilitating communication about medical images by computer-based collaboration on local and wide area networks increased rapidly with the progress in technology and the extension of high speed networks. The applications range from case conference systems (for example in teleradiology [1]) over advanced telemedicine services using image processing and hypermedia (e. g. [2] and [3]) to integrated medical information processing approaches covering computer-based (tele-)cooperation as one facet of daily work with a meta-patient record [4]. Despite numerous promising pilot projects a broad utilisation of the new technical possibilities failed so far for several reasons: Lack of an international or even national (multimedia) patient record standard; insufficient functionality and availability of the DICOM standard for medical images; especially in Europe: high costs for communication and political barriers [5]; lack of really matured telemedicine applications proven to save time and costs (the most precious goods in modern health care) and to improve quality (especially the human factors of such complex applications are neglected [6]); unsolved security problems [7].

With this background the telematic project MEDISA (MEDical Image and Signal Analysis, sponsored by the Association for Advancing a German Research Network, DFN-Verein, as RTB-Bayern 3.10 subproject) was started at the hospital Klinikum rechts der Isar of the Technical University of Munich (TUM) in September 1994. The objective is to implement prototypes of distributed medical applications supporting collaboration with emphasis on medical images, which require high band width communication links. As far as possible, existing standard software is utilised.

II. Background to the Projects

At the university hospital Klinikum rechts der Isar of the TUM two physically separated fibre optic networks have been installed: (1) A closed Corporate Network (CN) for the hospital information system to support patient care. Here sensitive data are communicated under protection against unauthorised access from outside. These data are medical and administrative patient data, personnel, financial and management data. (2) An open Scientific Network (SN) for research and education with connection to the german Breitband-Wissenschaftsnetz (B-WiN) which is part of the Internet. At present the connection of the two networks by a commercial firewall solution is in the implementation phase. With this firewall a controlled gateway transfer of anonymised or uncritical data out of the CN into the SN can be initiated by authorised users

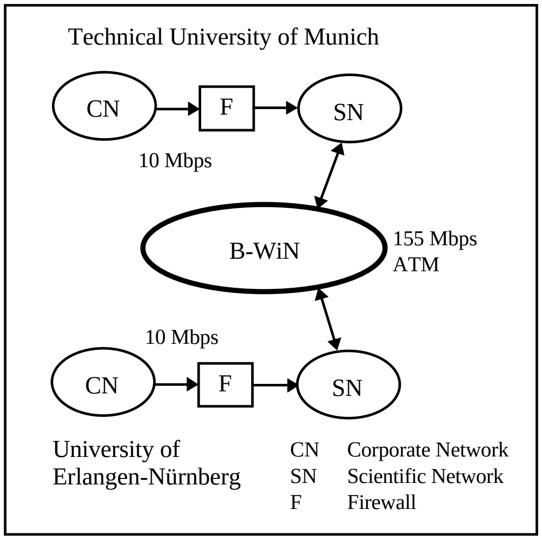

Figure 1: Network structure

of the hospital information system. All prototypes are implemented in the open SN. They use anonymised data from the clinical routine provided on dedicated servers in this network.

One project partner is located in Erlangen, about 200 km from Munich. Between Munich and Erlangen a 155 Mbps ATM link is available. It is shared with other running projects of the DFN-Verein. The local infrastructure works with 10 Mbps Ethernet at the moment. The update to 155 Mbps ATM or 100 Mbps FDDI is planned for the 4th quarter of 1996 in the backbone and to selected front-ends. Figure 1 gives a schematic overview on the network structure.

III. A Medical Informatics Research and Development Collaboration

Here we have a typical situation for a university environment: Physicians in a clinic at the university hospital cooperate with experts for image analysis at the Institute of Computer Science of the Technical University of Munich in order to investigate methods for automatic analysis of endoscopy and endosonography data to support medical decision making.

In the project RECIPE (REmote Cooperative Image Processing in Endoscopy, RTB-Bayern subprojects 3.10.2.I/II) the interpretation of video endoscopy and endosonography data from the gastrointestinal tract is supported. In close collaboration image analysis processes are developed which allow (1) an automatic detection of the location of the endoscope: oesophagus, stomach, duodenum, etc. out of the video endoscopy data, (2) the recognition of pathological structures, especially tumors and ulcers, also from the video data, and (3) segmentation and measurement of the depth of a tumor from endosonography data.

During the collaboration digitised images and image sequences from the clinical routine are transferred to the developer via file transfer. In the endo-

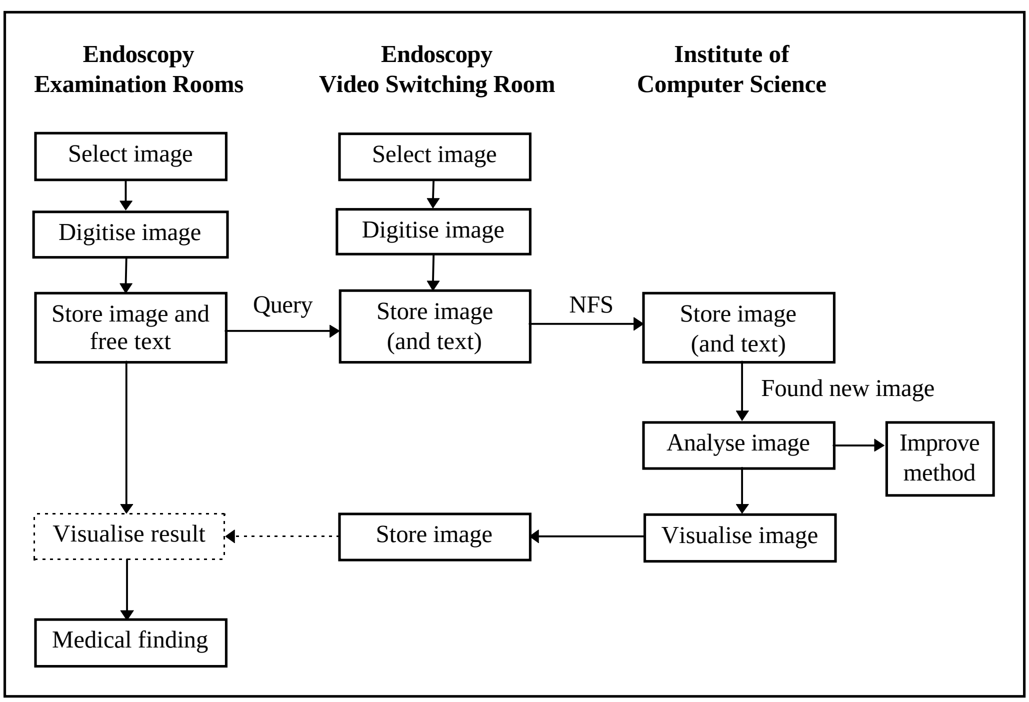

Figure 2: Cooperation Process for Endoscopy Image Analysis

scopy department the subsystem ENDOBASE of the OLYMPUS Corporation is operating for acquisition (digitisation), administration and archiving of the images as well as for medical documentation. In the ongoing development phase, image samples can be directly grabbed from the video outputs of the endoscope systems during the patients examination without patient information, i. e. anonymised. After patient examination and documentation they can be retrieved from the ENDOBASE system and stored anonymised on the project image server. The images are transferred via PC-NFS from the clinic platform based on DOS/WINDOWS to the UNIX workstations in the Institute of Computer Science. Here they are analysed with the image analysis system HORUS. Up to now, the endoscopy doctor records in addition to the image sequence the location of the endoscope and/or pathological structures he recognised in the image during the examination as free text in the ENDOBASE patient record. This information is transferred to the cooperation partner as gold standard for the evaluation of the developed image analysis methods. A rough scheme of the cooperation process is given in figure 2.

Preliminary results of the so far developed image analysis methods are quite promising. Processing of ultrasonic data with a training sample of 80 images brought a rate of 77 % for correct classification of tumors. The doctors appreciate the support gained by the computer application due to the objective and reproducible results. So far, they use it for selected cases. After further improvement of the classification rate (150 more training samples are planned) and implementation of on-line visualisation of the results during examination the application shall be fully integrated into clinical routine.

IV. A Patient Treatment Collaboration

High quality treatment planning based on modern medical 3D imaging is a prerequisite to careful radiation therapy for tumor patients.

The Clinic of Radiation Therapy of the TUM treats certain tumor patients with neutron irradiation. For this purpose 3D radiation plans are prepared on a special computer-based planning system from SIEMENS Corp. on DEC Alpha under VMS in the clinic. Basis of the planning process are X-rays, MRI and CT scans imported into the planning system by magnetic tape from the Department of Radiology. In addition, the images are provided on conventional film. Each day the films and hardcopies of the treatment plans (high quality video prints) are transferred by car to the nuclear research reactor of the Department of Physics in Garching, a small town 30 km from Munich. Here the treatments take place.

To support this complicated and insufficient process, in the project RIARAT (Remote Image Access for RAdiation Therapy, RTB-Bayern subproject 3.10.1) an OS/2-based client-server application on high-end PENTIUM 120 PCs has been installed between treatment and planning site. Using the client workstation in the Department of Physics the doctor has on-line access to the treatment plan. The X-rays, MRI and CT scans of the patient are stored in a directory hierarchy on the server in the clinic. That means a significant improvement of treatment quality: Checks and eventually necessary modifications of the treatment are supported by an interactive visualisation of the plan and the image data on the screen. Such simple facilities as interactive adjustment of contrast, brightness and displayed grey-scale window already yield a significant benefit.

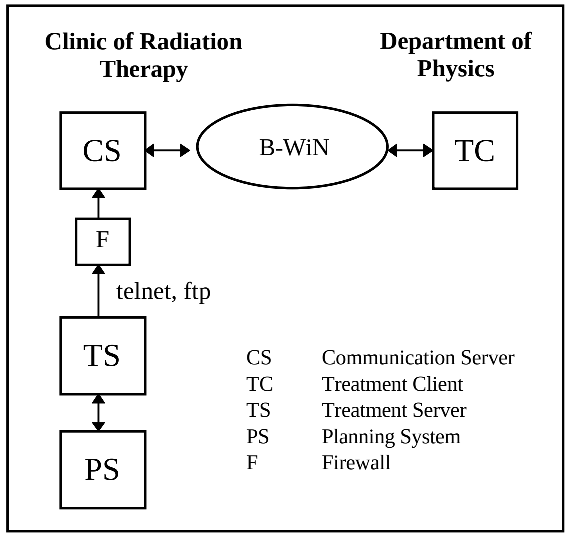

Figure 3: Technical Configuration for Treatment Collaboration

The collaboration between treating physician at the reactor and radiation therapy experts in the clinic is further supported by a teleconferencing system (IBM Person-to-Person, P2P) installed on the same configuration.

Figure 3 shows the system configuration of the application. The Planning System (PS) is connected with the Communication Server (CS) via TCP/IP. The data transfer is carried out using TELNET and FTP. The CS is connected to the hospital corporate network. On the CS the patient data are anonymised and the images are converted into standard TIFF file format. Then they are transferred to the Treatment Server (TS) via FTP through the firewall. For these purposes REXX scripts have been written to automate the process. The TS is an OS/2 workstation running 24 hours a day as FTP and multimedia server. Via Internet it communicates with the Treatment Client (TC) located at the nuclear reactor. On both machines runs OS/2 Warp Connect with TCP/IP, the ImPos/2 image processing tool and MultimediaView for visualisation. The storage capacities, 4 and 2 GByte, are sufficient to execute preloading of data to the TC before the treatment session starts. The video conferencing system Person-to-Person from IBM Corp. is running on the TS-TC couple and provides the teleconsultation facility.

The acceptance of the application in the day-to-day work of the doctors is good. They especially like the provided visualisation facilities. There are also some crucial improvement requirements. Remote on-line planning on the PS is the most important one.

V. A Medical Research Collaboration

The benefit of a diagnostic method depends not only on the quality of the method itself, but is also highly dependent on the experience of the physician who interprets the acquired data. This especially applies to endoscopy images. In a clinical study at the University of Erlangen-Nürnberg the utilisation of endoscopy for the monitoring of patients with a Barrett oesophagus, a metaplasy of the oesophagus, is evaluated. In order to eliminate biased judgement, a second expert opinion is required.

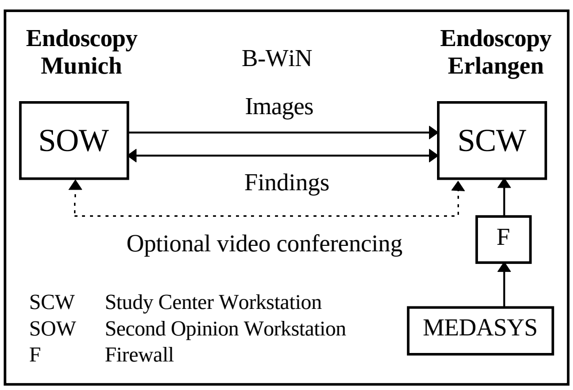

Figure 4: Configuration for Medical Research Collaboration

In the project SECOPE (SECond OPinion in Endoscopy, RTB-Bayern subproject 3.10.2.III) a distributed image communication application based on FTP and teleconferencing has been implemented. The configuration is shown in figure 4. Heart of the application is the communication couple consisting of the Study Center Workstation (SCW) on the one side and the Second Opinion Workstation (SOW) on the other. The digitised endoscopy images and image sequences are transferred from Erlangen to Munich on a 155 Mbps ATM link, and locally on 10 Mbps Ethernet to the workstations. The solution is based on OS/2 high-end PCs with 21“ screens and the software tools Person-to-Person and ImPos as in the treatment collaboration project described above.

The complex collaboration process between the two clinics is shown in figure 5. In the morning patients are examined in the clinic in Erlangen. After admission the patients are registered in the MEDASYS endoscopy subsystem (PENTAX Corp.). Patients with Barrett oesophagus or suspicious finding are further examined to capture at least 20 more endoscopy images. After the images have been stored and the finding has been documented in MEDASYS by the doctor and his assistants the data are prepared for the transfer to Munich. When desired, the examinations of 3 or 4 patients are collected. After transfer to the scientific network through a firewall the images are stored on the SCW (compare figure 4) for an optional video conference with Person-to-Person (P2P) and for the transfer to Munich. On the SOW a small single user installation of the MEDASYS system is used to process the anonymised examination data. The expert records his finding with this system, optionally supported by a video conference held with the colleagues at the study center in Erlangen to fix open questions, but of course not about the finding.

It has been rather difficult to implement this application, mainly due to the problem that doctors in Erlangen and Munich had been accustomed to different baseline colors caused by the different endoscope systems. Meanwhile, a color standardisation has been implemented. The application is now accepted and appreciated within the clinical study.

VI. Concluding Remarks

The experiences made during the first half of the projects’ two year runtime have shown that besides the above mentioned specific difficulties there are essentially three problem areas that force intermediate and sometimes ad hoc solutions: (1) the strict separation of corporate network and scientific network necessary for the lack of a national or international corporate network for health care and unsolved security problems; (2) insufficient interoperability of medical subsystems due to the fact that communication standards are not available to the extent needed for advanced integration and collaboration; (3) the processes in patient care and medical research to be supported by computer-based cooperation are in most cases much more complicated than expected.

Nevertheless, the benefits of the implemented application prototypes have already been widely recognised by the users in the projects described

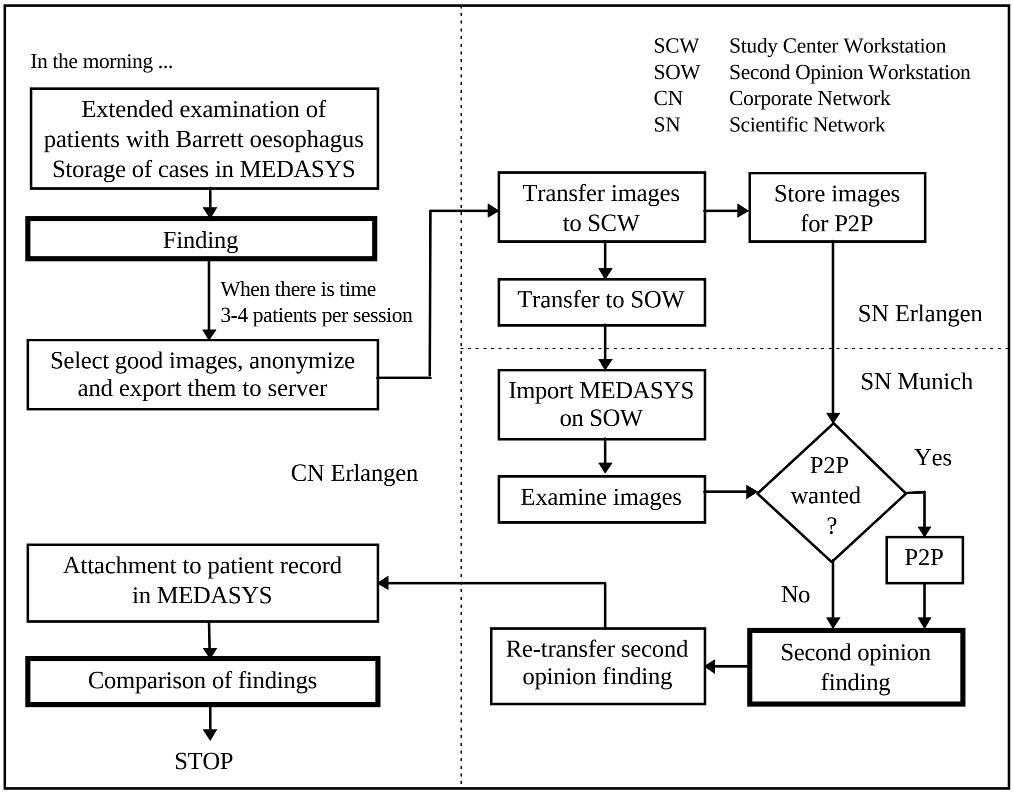

Figure 5: Second Opinion Finding Process

above. Detailed and quantified answers about the acceptance and the benefits of the applications will be given in the evaluation phase starting in the beginning of 1996.

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