Computer Supported Cooperative Work and Image Analysis in Teleradiology

H. Handels[1], Ch. Hahn[1], J. Miehe[2], A. Will[3], P. Bernardes[4], Ch. Busch[4], V. Kühn[4], E. Rinast[5], H. Putzar[6], K. Rösler[6]

[1]Institut für Medizinische Informatik and [5]Institut für Radiologie, Medizinische Universität zu Lübeck, Ratzeburger Allee 160, 23538 Lübeck, Germany.
[2]Zentrum für Graphische Datenverarbeitung e. V. and [3]Fraunhofer Institut für Graphische Datenverarbeitung, Joachim-Jungius-Str. 9, 18059 Rostock, Germany.
[4]Zentrum für Graphische Datenverarbeitung e. V., Wilhelminenstr. 7, 64283 Darmstadt, Germany.
[6]Radiologische Klinik, Universität Rostock, Gertrudenplatz 1, 18057 Rostock, Germany.

Summary
For ISDN based image exchange, consultative discussion, and image analysis in teleradiology the software system KAMEDIN (**K**ooperatives **A**rbeiten und **ME**dizinische **D**iagnostik auf **I**nnovativen **N**etzen) has been developed [1]. During teleconferences user interactions for image processing etc. are synchronised and performed simultaneously on different workstations using functions of computer supported cooperative work (CSCW). For computer assisted diagnosis remote tissue segmentation and classification in intracranial MR data can be performed via ISDN with neural network classifiers on an external supercomputer.

Introduction

In practice, patient examination and treatment are often necessary in several departments or clinics. Hence, image interchange and consultative discussions of medical images are needed between different departments i. e. radiology, neurosurgery, or orthopaedics [2]. To support telecommunication and computer supported cooperative work (CSCW) in teleradiology the software system KAMEDIN makes use of ISDN (**I**ntegrated **S**ervices **D**igital **N**etwork) S_0 basic rate interface (BRI), which is a widespread and inexpensive communication medium. The BRI bandwidth of 144 kbit/s is divided into three channels: Two B-channels for data transfer with a bandwidth of 64 kbit/s each and additionally one D-channel for the transfer of control information with 16 kbit/s. In the software system KAMEDIN techniques for computer supported cooperative work are used to synchronise operations and interactive processing of medical images in teleconferences. Furthermore, for diagnosis support remote image analysis and tissue recognition methods can be applied.

Teleconference

In a first step, image data transfer is carried out beforehand by a background process. After completion of the image transmission a teleconference can be initiated. During a conference image data can be viewed and analysed with standard imaging tools common in radiology departments (Figure 1). These include functions like measuring of density and distance, windowing, zooming, single slice view, multiple slice view etc.

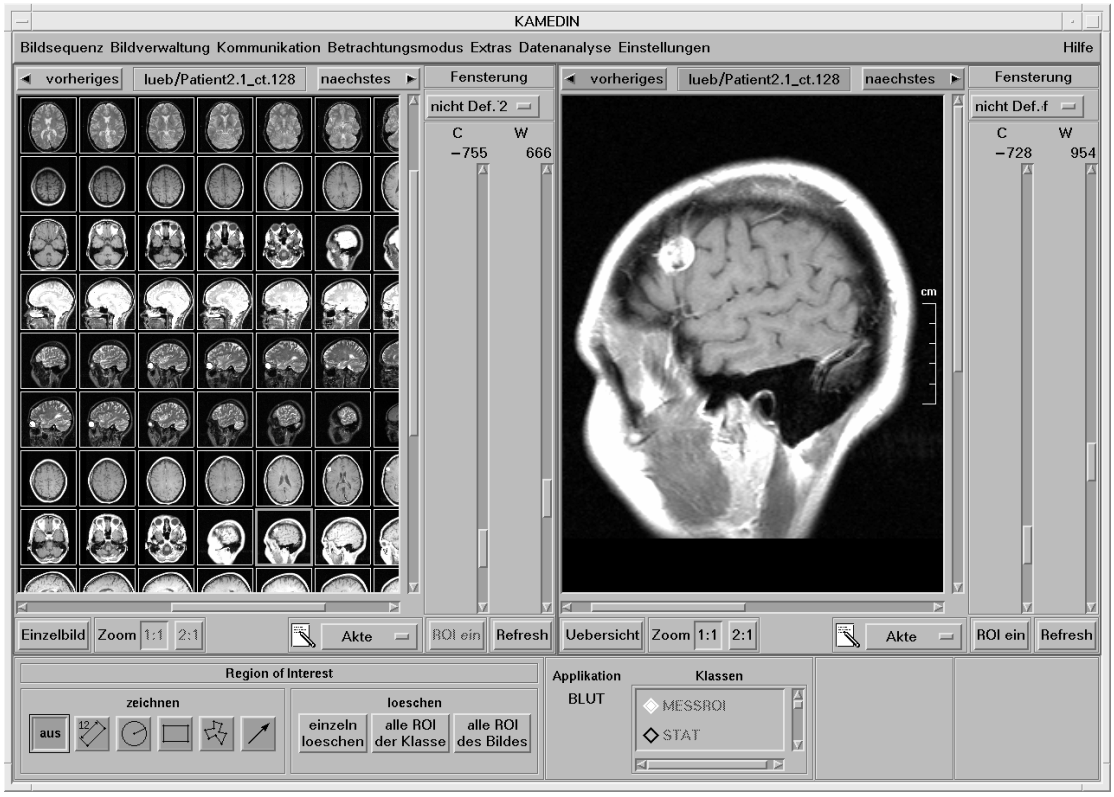


Figure 1: KAMEDIN user interface with a sequence overview of a MR sequence in the left and a single saggital slice image with a brain tumour in the right window.

During a teleconference user interactions are synchronised and resulting actions are quasi-simultaneously performed on both partners' workstations. For synchronisation, actions and image processing operations can only be activated from one teleconference partner. The partner's mouse position is permanently visible as a remote cursor making telepointing possible. In addition, an audio connection is realized via ISDN simultaneously.

System Structure

For cooperative work in teleradiology the following modules and UNIX processes are implemented in the software system KAMEDIN: user interface, image processing, session manager, and the KAMEDIN daemon (Figure 2). Furthermore, software modules for image file transfer and execution of supercomputer batch jobs are integrated. The KAMEDIN daemon is the root process. It is realized as a UNIX background process and represents the bridgehead to the ISDN network (Figure 2). Process communication uses defined data structures of fixed length, the so-called KAMEDIN commands. During a teleconference the session manager organizes and controls the synchronisation and the transfer of KAMEDIN commands. Each command is duplicated and transferred via ISDN to the conference partner's workstation. All commands are transmitted using the TCP/IP protocol, which is mapped down to the ISDN protocol.

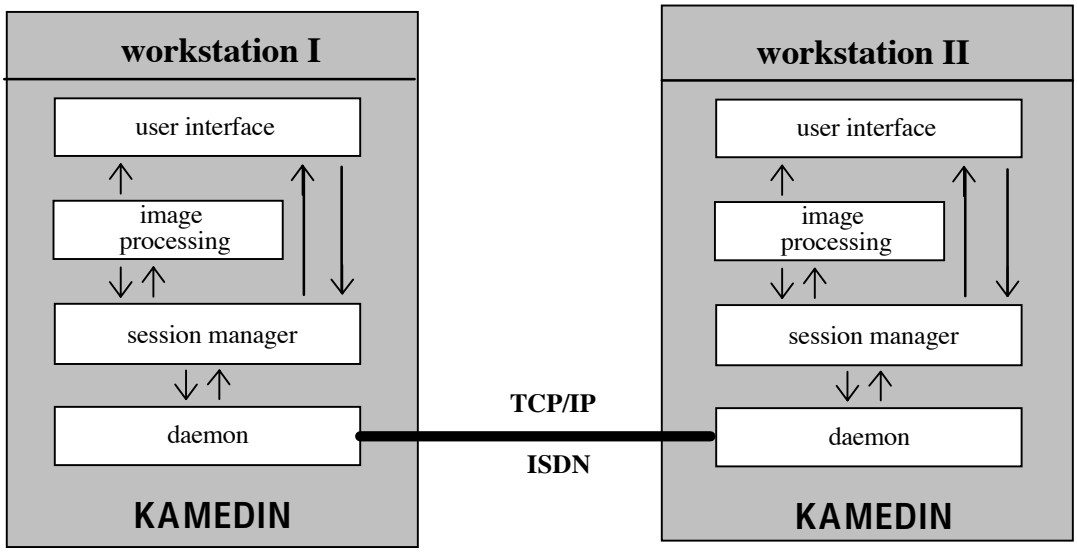


Figure 2: Architecture of the software system KAMEDIN

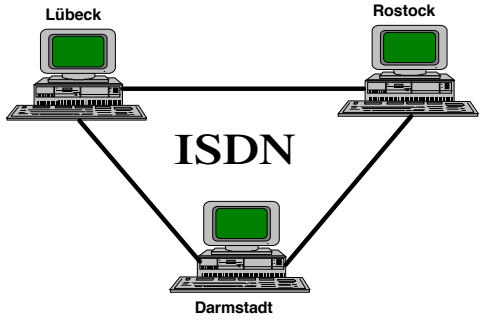
Furthermore, the conference partners' mouse positions are transmitted permanently in both directions for telepointing. The result is a quasi-parallel execution of the respective actions and a continuous display of both local and remote cursor on the conference workstations. KAMEDIN has been developed in the programming language C under the operating system UNIX. The graphical user interface is based on X-Windows and OSF-Motif.

Telesupercomputing for Image Analysis

To support diagnosis of intracranial MR image data sets artificial neural networks have been developed for automatic brain tissue segmentation and classification. Multilayer perceptrons and Kohonen feature maps [3-5] are currently evaluated for this purpose. They operate on feature vectors extracted from multi-spectral MR data sets by means of texture analysis [1,3]. For effective training, databases containing regions of interest interactively drawn and labelled by experts are successively built up. After sufficient training, brain tissues in unknown data sets can be classified by the neural network. As classification result, each pixel of the analysed data set is labelled with a tissue index that encodes a tissue specific colour. 3D views can be generated from these classification results using PHIGS+. Training and classification require high computational performance. They are carried out off-line using a supercomputer (Siemens-Fujitsu S400/40). Images to be classified are transmitted to the supercomputer via ISDN in a so-called supercomputer batch job. After completion, classification results are sent back and can be visualised with KAMEDIN.

Conclusion

KAMEDIN is a tool to support cooperative work and remote image analysis in teleradiology. Data exchange and cooperative teleconferences can be performed easily and with reasonable communication costs via ISDN. Furthermore, the used ISDN basic rate interface is available for everybody in Germany.



A prototype has been implemented and will be tested under clinical conditions in different medical environments in 1995. 15 hospitals, neurosurgical and radiological departments are involved in the region of Darmstadt, Rostock and Lübeck.

To operate with KAMEDIN one needs a workstation with an 8-bit-graphics adapter, an ISDN adapter, at least 16 Mbytes of memory, and harddisk storage capacity according to the expected data volume. In 1995, a PC-version of KAMEDIN will be implemented. Furthermore, software components for multipoint teleconferences, communication via EURO-ISDN and an interface to PACS systems will be developed.

Automatic classification results are still being evaluated at the present stage. Good generalisation results of the neural networks require a sufficient amount of training data for each tissue type to be recognised. Therefore, MR image sequences with brain tumours are investigated in a study to successively expand the databases.

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