ISDN BASED TELERADIOLOGY AND IMAGE ANALYSIS WITH THE SOFTWARE SYSTEM KAMEDIN

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ABSTRACT

This contribution describes the software system KAMEDIN (**K**ooperatives **A**rbeiten und **ME**dizinische **D**iagnostik auf **I**nnovativen **N**etzen) that is designed as an ISDN based computer supported cooperative work (CSCW) tool for usage in medical diagnostics. Medical image data from various sources (for example CT and MR) can be interchanged and analyzed in bilateral teleconferences via ISDN. During a cooperative session user interactions for image processing etc. are synchronized and performed on both workstations. Features like telepointing, remote control, and audio connection enhance communication quality. With ISDN as transmission line widespread availability and low communication costs are achieved. Further, automatic tissue labeling in intracranial MR data can be invoked. For this purpose artificial neural network classifiers such as multilayer perceptron and Kohonen feature map are integrated. Classification results can be viewed as 3D-reconstructions.

1. INTRODUCTION

Increasing specialization frequently makes patient examination and treatment in more than one department or surgery necessary. Expert advice on difficult image based diagnostical problems is needed. Also, modern image acquisition equipment like magnetic resonance (MR) and computer tomographs (CT) is increasingly centralized. Image data therefore has to be exchanged and discussed, preferably without wasting precious time. Hence, the demand for communication infrastructure has decidedly increased. This infrastructure should include techniques for synchronization of interactive image processing by physicians in different places. Whereas networks with large bandwidth (like FDDI) seem to be feasible within a hospital [5], long distance communication requires a widespread and less expensive transmission medium. KAMEDIN's approach [1] therefore is to present a powerful low-cost CSCW tool using standard ISDN (**I**ntegrated **S**ervices **D**igital **N**etwork). KAMEDIN's functions cover:

- image data handling and exchange
- teleconferencing
- supercomputer integration for automatic tissue classification.

KAMEDIN makes use of the most common ISDN interface in Germany, the so-called basic rate interface (BRI). The BRI bandwidth of 144 kbit/s is divided into three channels: Two B (bearer) channels carrying user information with 64 kbit/s each and one D channel carrying signaling information with 16 kbit/s. Communication costs are comparatively low: Approximately 25 US$ per hour communication time plus 50 US$ per month for the service. The disadvantage of small bandwidth is met with an according system architecture.

2. IMAGE DATA HANDLING AND TRANSFER

An on-line transfer of image data during a conference via small bandwidth ISDN would be by far too time consuming (MR data sets easily amount to 30 Mbytes or more per patient). Therefore, KAMEDIN's approach is to carry out the image data transfer *beforehand*. Preferably during low fee hours the respective data is transmitted via ISDN by a background process. For this purpose data of one or more patients is copied into a so-called conference folder. A conference folder also contains additional information concerning patients, data and the requested teleconference. Tools like a filemanager, an internal directory, etc. allow their flexible handling. A conference folder has to be successfully transmitted before a teleconference. Both partners then have all the data to be discussed and preliminary information already available on their workstations during the actual conference. Hence, only commands concerning session status and user interactions have to be transmitted during a cooperative session.

Standardized image data handling within KAMEDIN and data integration from various possible image acquisition apparatuses require a conversion of original data. The conversion into a KAMEDIN specific file format consists of the following steps:

- Separation of header and actual image data.
- Conversion of raw image data into the TIFF file format.
- Generation of description files containing sequence or image specific information retrieved from original image headers.
- Generation of a sequence overview containing all the images of a particular sequence on a smaller scale (Figure 1). Images can be selected from the sequence overview by mouse click for loading and further processing. Thus, the handling of even very large sequences is facilitated.

Figure 1. KAMEDIN user interface with a sequence overview of a MR sequence in the left and a single slice view of a contrast enhanced axial slice showing a meningeoma in the right window

3. TELECONFERENCE

After completion of the preliminary tasks (chapter 2) a teleconference can be initiated. A point-to-point ISDN connection between the two partners is then established. During a conference, image data can be viewed and analyzed with standard imaging tools common in radiology departments. These include modalities for single slice view, multiple slice view, zooming, measuring of density and distance, windowing, etc. (Figure 1). User interactions are synchronized and resulting actions are quasi-simultaneously performed on both partners' workstations. In order to prevent collisions between contrary interactions of the two partners, one partner is in possession of a token. The token provides him with the control of the session and allows only him to perform image processing operations. By request the token can be interchanged during the teleconference. The partner’s mouse position is permanently visible as a remote cursor. Thus, his moves are always transparent and telepointing is possible. Regions of interest can also be drawn in this manner. In addition, an audio connection is realized to support the visual communication elements.

4. AUTOMATIC TISSUE CLASSIFICATION

To support diagnosis of intracranial MR data sets artificial neural networks are integrated for automatic brain tissue segmentation and classification. Of particular interest is lesion detection. Multilayer perceptrons and Kohonen feature maps [2-4] are currently evaluated for this purpose. They operate on feature vectors extracted from multimodal MR data sets by means of texture analysis. Multimodal MR data sets are for example double-echo sequences or sequences measured before and after administration of contrast agent. For effective training, databases containing regions of interest interactively drawn and labeled 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 analyzed data set is labeled with a tissue index that encodes a tissue specific color. 3D views can be generated from these classification results using PHIGS+.

Because training and classification require high computational performance they can be 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 batchjob. After completion, classification results are sent back and can be visualized with KAMEDIN.

5. SYSTEM ARCHITECTURE

KAMEDIN consists of several modules, represented by a number of UNIX processes. Root process is the so-called KAMEDIN daemon (a UNIX background process) that also represents the bridgehead to the ISDN network. Other important processes are the session-manager, the user interface, and file transfer processes (Figure 2).

Communication between processes uses defined data structures of fixed length, the so-called KAMEDIN commands. Other processes are activated by writing KAMEDIN commands into UNIX-fifos (first in first out) associated to them. All commands intended for the remote workstation use the TCP/IP protocol, which is mapped down to the ISDN protocol.

For session start-up the respective KAMEDIN command is transmitted to the remote daemon. A running daemon and entries in security tables allow another workstation to connect for a KAMEDIN session. Once a session is established user interactions are treated by the session manager. If an interaction is a) of relevance to the conference partner and b) the originator is in possession of the token, the respective command is *duplicated* for execution on both the local and remote workstation. The duplicated version is transmitted to the remote daemon via ISDN. The remote session manager in turn sees to its execution. The result is a quasi-simultaneous execution of the respective action on both workstations without a noticeable lag.

To operate KAMEDIN each prospective partner needs an ISDN workstation with an 8-bit-graphics adapter, at least 16 Mbytes of memory, and harddisk storage capacity according to expected data volume. KAMEDIN has been developed in the programming language C under the operating system UNIX. The graphical user interface is based on X-Window and OSF-Motif.

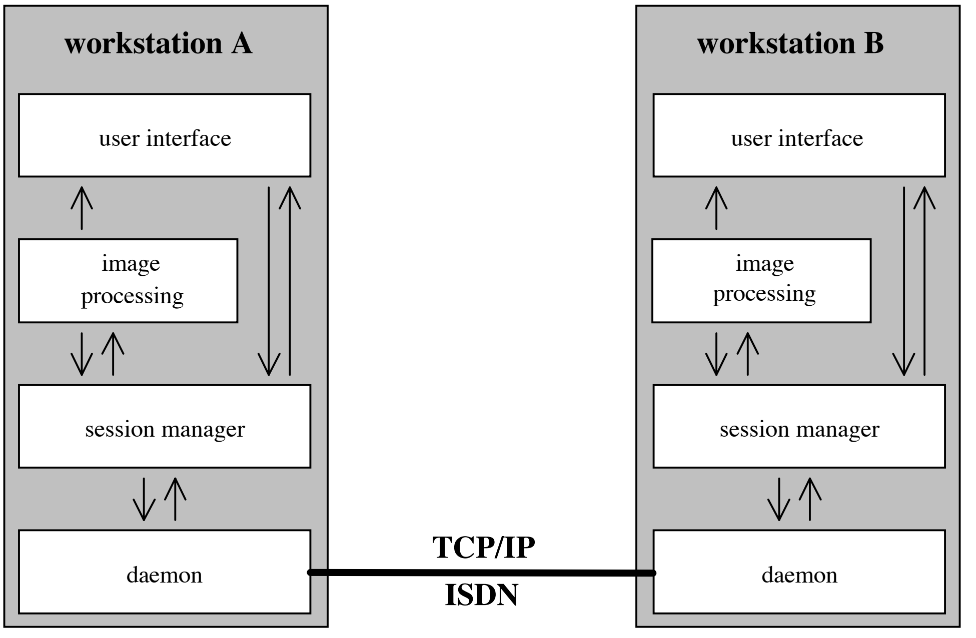

Figure 2. System architecture

6. CONCLUSION

A prototype of KAMEDIN has been implemented and is in use between the involved groups and medical partners. Possible medical applications cover a wide range and are not restricted to radiology departments. Easy handling, reasonable communication costs, and good performance despite small bandwidth ISDN as transmission line are the advantages of the system. The wide applicability of an ISDN based system as opposed to high speed transmission lines seems to be particularly of interest to prospective users: ISDN is available practically for everybody in Germany. With European standardization efforts almost completed an extension is within reach.

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

With all its features KAMEDIN might turn out to be not only a tool for teleradiology, but also for easily accessible high-level image analysis and visualization methods.

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7. REFERENCES

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