9 A Web-based Teaching and Training Network in Neurosurgery

Herbert K. Matthies

Institute of Medical Informatics
Hannover Medical School, 30623 Hannover, Germany
matthies.herbert@mh-hannover.de

Abstract

The era we are living in is often referred to as the "information age" because new information and communication technology (ICT) has had an enormous influence and a revolutionary impact to change the way we do business, live and learn. New educational concepts, technologies and course contents will be required with consideration of topics, e.g.

- Teaching/learning strategies,
- E-learning environments,
- Development and production of learning modules,
- Web-based learning resources/tools,
- Virtual learning labs/classrooms in conventional universities,
- Collaborative learning in small groups,
- Policies, ethics, worldwide (EU) standards.

These new ICT systems open up new forms and ways of learning.

In the German Federal Ministry of Education and Research (BMBF) granted project "Teaching and Training Network in Neurosurgery" (TT-Net), modern multimedia and information technology is used in the hospital in order to leverage it for the training of students and physicians. The aim is to compose web-based course modules for a virtual education system for neurological diseases. The TT-Net is being realized in a very well equipped and highly competent learning environment in the Hannover Medical School campus network (see figure 1).

Keywords: life long learning, volume visualization, virtual education system.

1. Introduction

Because web browsers are becoming the universal front-end for multimedia applications, learning is not limited by geography and does not cause pressure of time by the user. The development of such multimedia information and communication systems demands cooperative working teams of authors, who are able to master several areas of medical knowledge as well as the presentation of these using different multimedia facilities. A very important part of communication design in the context of multimedia applications is the creation of screen design, both of icons and buttons, and interactive use of images and video-clips. The growth and complexity of medical knowledge as well as the need for continuous, fast, and economically feasible maintenance impose requirements on the media used for medical education and training. An efficient content creation and production of web-based courseware is necessary. It is an innovative education resource for medical students and professionals.

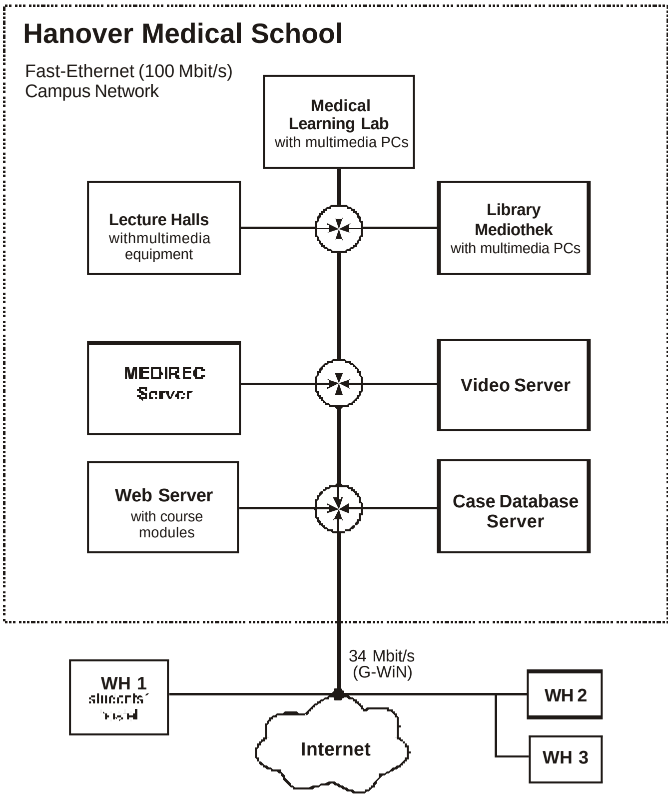

Figure 1: TT-Net Sever in the Campus Network

2. Using web technologies for education

The theory and practice of education are undergoing dramatic changes. Lifelong learning and adaptation of medical practice to new knowledge and new techniques will be even more important. The focus will move on from conventional teacher based lectures to virtual learning centers. How do we support successful lifelong learners and help them to competently respond to the rapidly changing opportunities in the 21st century? In addition to and in combination with classroom courses, the development of internet-based multimedia courseware is significant (Matthies, 2000).

Web technologies support smarter learning, make it possible to better manage changes, continually improve learning, and offer an efficient representation of contents. Instructions provided through Web-based learning environments should incorporate active learning models to make it possible for students and physicians to take an active role in their learning. Information skills are needed for problem solving. Related information skills should be developed within the context of real need and the overall information problem solving process. Learning means understanding. In addition to passively receiving information in the classroom, learners are invited to actively explore the medical knowledge in a virtual learning environment designed with flexible jumping (buttons) to virtual learning rooms.

3. The virtual learning room concept for the TT-Net at the Hannover Medical School

Our virtual learning room concept (see figure 2) to use web-based learning environments has been realized with consideration of both systematic learning and problem-based learning.

Figure 2: Buttons for virtual learning rooms of the TT-Net

For example, the “Orientation”-button (see figure 3) always gives information about the current virtual learning room.

Every learner may select different learning levels and has also the possibility to test his knowledge using multiple choice questions (see figure 4) as they would be given in real examinations. The SQL database system responds with “Your answer is correct” (see figure 5) or “Sorry, your answer is incorrect”. Incorrect answers will be color labelled.

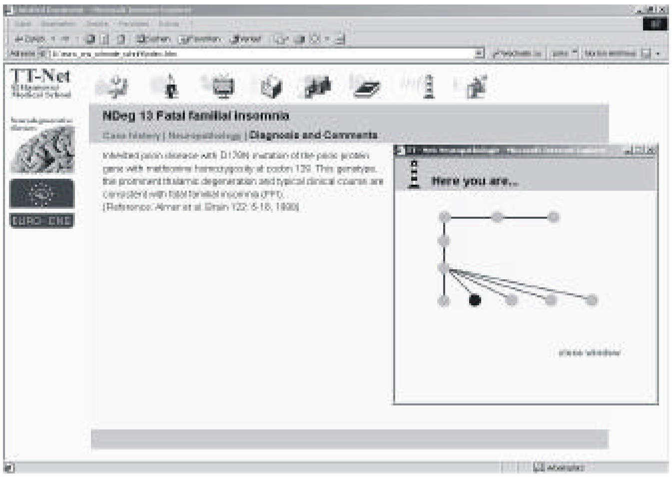

Figure 3: Orientation-Button

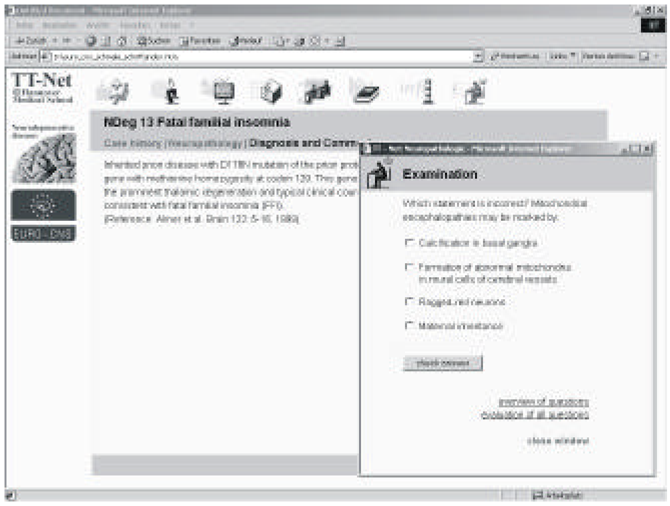

Figure 4: Test using multiple choice questions

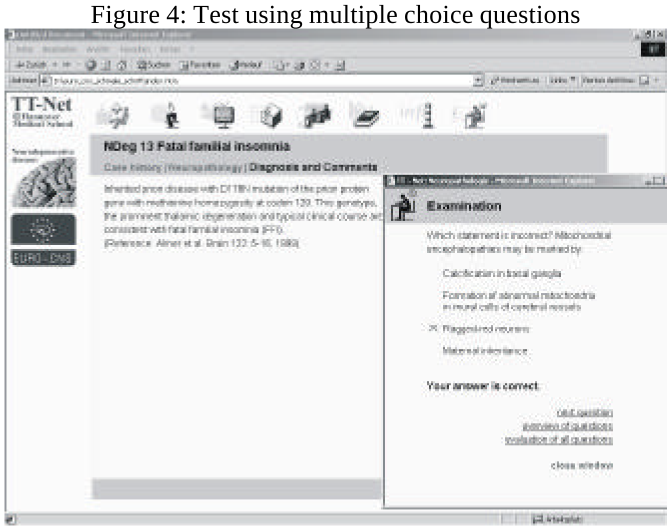

Figure 5: Test results

4. Content of TT-Net

The aim is to build a web based textbook for teaching basic knowledge in neurosurgery. This textbook contains text, hyperlinks, video-clips (see figure 7), animations and virtual reality scenes as well as digital radiographs (DICOM). The teaching of surgical skills by means of multimedia based materials, i.e. "learning by viewing" will minimize "learning by doing" for surgical training. Through the use of three-dimensional (3D) models and volume visualizations of real patient data (e.g. CT or MR), the student's spatial orientation in the datasets is greatly facilitated, which is an important aspect for learning how to plan and perform surgical procedures. Contrary to what can be shown by conventional drawings, 3D models and volume visualizations show the anatomy in a quantitative way and make it possible to interactively view the scene from every imaginable and desired perspective.

4.1. The learning module "Basic procedures in Neurosurgery"

The first step is to compose a multimedia learning module "Basic procedures in Neurosurgery" (see figure 6), containing text, hyperlinks, video-clips, animation, VR environments (Virtual Reality) and digital radiograms (DICOM).

Figure 6: Screenshot of the content page of the learning module "Basic procedures in Neurosurgery"

The web-based textbook contents are diagnosis oriented, and based on the subject catalogue (GK) of the disciplines Neurosurgery, Neuropathology and related fields. The textbook material is generated from a collection of case examples acquired from the involved clinical institutes containing electronic data of neurosurgical procedures and case reports as well as digital patient records.

German cooperation partners of the Hannover Medical School are the Clinics of Neurosurgery of the Humboldt University (Charite) in Berlin and of the University Erlangen, the Institute of Neuropathology of the Saarland University in Homburg/ Saar and the International Neuroscience Institute Hannover.

The learning modules for "Neuropathology" in the TT-Net are developed for students' level. They are the base for the development of a virtual education system within of the framework of the continuing training courses of the Confederation of Neuropathological Societies (EURO-CNS).

Figure 7: Video-clip of a neurosurgical procedure

4.2. EURO-CNS Virtual Education System

This system is based on the software for the TT-Net modules for neuropathological Images and Cases (see figure 8) developed by the Institute of Neuropathology and by the Institute of Medical Informatics of the Hannover Medical School. A special adaptation for the needs of EURO-CNS, including a refinement of the software in cooperation with specialists for communication design and media pedagogics, is foreseen.

Figure 8: Case report with histological images

The scientific contents will be decided and controlled by the educational board of EURO-CNS. The language will be English, but in principle the system is adaptable to all languages and script types, e.g. Greek or Cyrillic.

The development and maintaining costs are borne by the institutes from Hannover Medical School, financed from available research grants.

The System will be accessible over the Internet websites of EURO-CNS and of Hannover Medical School. The access can be limited by password to members of EURO-CNS societies, if wanted.

This System should/could contain

- the cases presented at the training courses, including prototypic images and case reports, for self-instruction and repetition;
- summaries and reviews of the topics of the training courses, provided by invited lecturers;
- the original questions of the European Board Examination organised by EURO-CNS during the European Congress of Neuropathology in Paris, in 1996, including multiple choice text and slide questions, for self testing; this is accompanied by an automatic evaluation and correction of the given answers;
- forthcoming EURO-CNS Board Examinations including automatic evaluation and correction;
- additional features decided by the educational board of EURO-CNS, such as enclosure of video-clips and/or audio-clips;
- links to well selected websites, e.g. the websites of EURO-CNS member societies can be established.

4.3. Volume visualization

The development of medical imaging over the past 30 years has been truly revolutionary. Three-dimensional volumetric visualization of CT and MR data of the spine, internal organs and the brain has become standard of routine patient diagnostic care. Volume data are 3D entities that may have information inside them, may not consist of surfaces and edges, or may be too voluminous to be represented geometrically. Volume visualization is a method of extracting meaningful information from volumetric data using interactive graphics and imaging (Kaufmann, 2000).

Volume rendering conveys more information than surface rendered images, but at the cost of increased algorithm complexity, and consequently increased rendering times. To improve interactivity in volume rendering, many optimization methods as well as several special-purpose volume rendering machines have been developed.

Commercial solutions for medical 3D visualization frequently use manufacturer-dependent and expensive hard- and software, which can not always be adapted to the needs in educational environments. Therefore, an efficient visualization tool with support for hard- and software based volume rendering according to our requirements was developed for use in student education (see figure 9). This tool is based on the open source software library VTK (visualization toolkit, version 4.0).

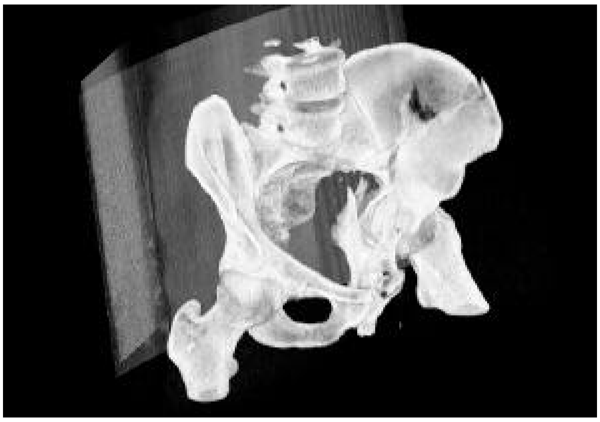

Figure 9: 3D view of a complex fracture of the pelvis

4.4. Quantitative 3D models of neurosurgical procedures

In addition, a new method is used to generate quantitative three-dimensional models of neurosurgical procedures (Köster, 2002). A computer assisted surgery (CAS) device (MKM of Zeiss, Germany) is used to scan optically discrete points of the outlines of surgically relevant structures in order to obtain 3D co-ordinates of the surgical scene. These data are applied to a computer aided design (CAD) software (AutoCAD LT 2000i, Autodesk), which allows quantitative 3D modelling. Using these data we obtained a CAD model of the surgical scene, which represents not only the intraoperative anatomy, but in addition information from the preoperative imaging. This new method of modelling neurosurgical procedures (Koester, 2002) enables a documentation of surgery with quantitative properties and is therefore unique compared to conventional film and photo documentation. The resulting model can be used to simulate different perspective views and to perform measurements within the model like exact localization and size of a craniotomy, spatula position and optical axis of the microscope at different stages of a surgery. Thus, this new method of modelling neurosurgical procedures allows accurate 3D documentation of intraoperative anatomy and surgical manipulation. It therefore provides basis data necessary for 3D modelling and simulation of neurosurgical procedures.

4.5. 3D rendering

3D rendering is recognized as an efficient educational tool to present human anatomy and included pathologies. In The Visible Human Project it is in use as an interactive 3D atlas. For 3D visualization, all anatomic structures of the body were precisely segmented, which is a very time and cost consuming task and is not feasible for larger databases, as detailed segmentation of each individual case is unreasonable. In a clinic, the high computing cost of direct volume rendering makes it difficult for sequential implementations and general-purpose PCs or workstations to deliver the targeted level of performance. This situation is aggravated by the continuing trend toward higher and higher resolution datasets. Therefore we started a project using a direct volume rendering technique to build a large-scale 3D database of pathological cases intended as an interactive learning tool for medical students (Shin, 2002).

Figure 10: Visualization of a centrally located bronchial carcinoma. The segmented tracheobronchial tree is embedded in the 3D volume.

Without radiological training, medical students were able to work with the case-based 3D presentations (see figures 10 and 11). With basic anatomic knowledge, they could interact with the different 3D data sets to gain a deeper understanding of the underlying pathology. All pathologies of the CT-angiography cases could be visualized using volume rendering techniques without time-consuming segmentation.

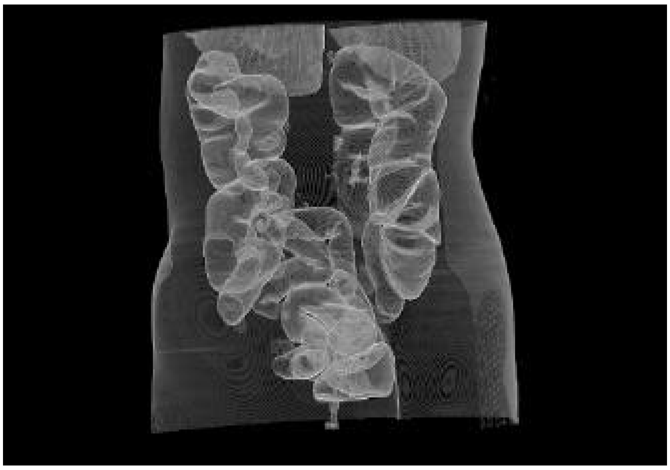

Figure 11: Visualization of the air filled colon

Acknowledgements

The support of the German Federal Ministry of Education and Research for funding of the TT-Net project (BMBF-08NM150 A) is acknowledged.

I would like to thank cordially the entire project team of the TT-Net for their great support. (More Information in the web: http://www.mh-hannover.de/institute/medinf/).

My special thanks are meant for the professors of medicine for the support and assembly of the case reports and video-clips for this cooperation project, mentioned the sub-project's heads:

Prof. W. Feiden, Inst. of Neuropathology, Univ. of Saarland, Homburg, Germany;

Prof. W. Lanksch, Neurosurgical Clinic, Charite, Humboldt Univ. Berlin, Germany;

Prof. M. Samii, International Neuroscience Institute (INI) Hannover, Germany;

Prof. C. Strauss, Neurosurgical Clinic, Univ. Erlangen/Nuernberg, Germany;

Prof. G.F. Walter, Inst. of Neuropathology, Hannover Medical School, Germany;

last, but not least I would like to thank the neurosurgeon Prof. Dr. T. Brinker (INI Hannover) for the chapter concept and the coordination of neurosurgical contents.

Further, I would like to thank Prof. Jan van Bemmel whose web-based "Handbook of Medical Informatics" (van Bemmel, 1997) has inspired much of my work.

References

van Bemmel, J.H. & M.A. Musen (1997). *Handbook of Medical Informatics*. Springer Verlag Heidelberg, and URL http://www.mieur.nl/mihandbook/r_3_3/handbook/home.htm

von Jan, U., H. Shin, H.M. Overhoff & H.K. Matthies (2002). Interactive PC-based volume rendering of CT datasets, *Biomedizinische Technik*, (vol.: 36. Jahrestagung der Dt. Gesellschaft für Biomedizinische Technik), i.p.

Kaufmann, A.E. (2000). *Volume visualization in Medicine*. In: Brinkman, I.N. *Handbook of Medical Imaging*. Academic Press San Diego - San Francisco - New York- Boston-London-Sydney-Tokyo, pp. 713-730.

Koester, I., A. Samii, T. Brinker & H.K. Matthies (2002). *A new method for 3D modeling of neurosurgical procedures*. In: Lemke H.U. et al. *Computer Assisted Radiology and Surgery*. Proceedings of CARS 2002, Springer-Verlag Berlin-Heidelberg-New York, pp. 1071.

Matthies, H.K., U. v. Jan, A.J. Porth, M. Tatagiba, A.C. Stan, G.F. Walter (2000). *Multimedia-based courseware on the virtual learning center at the Hannover Medical School*. In : Studies in Health Technology and Informatics, vol. 77: Hasman, A. et al. (Eds.): *Medical Infobahn for Europe*. IOS Press Amsterdam, Berlin, Oxford, Tokyo, Washington DC, pp. 541-545.

Shin, H., U. v. Jan, M. Galanski & H.K. Matthies (2002). *Interactive tutorials: development of a large scale 3D database of pathological cases using interactive* *volume rendering technique*. In: Lemke H.U. et al. *Computer Assisted Radiology and Surgery*. Proceedings of CARS 2002, Springer-Verlag Berlin-Heidelberg-New York, pp. 473-476.