MEDINFO 98
B. Cesnik et al. (Eds)
Amsterdam: IOS Press

Concepts of a Web-based Open Distributed Textbook for the Multimodal Diagnostics of Gastrointestinal Tumours with MRI, CT and Video-endoscopy Addressing Students of Medicine and Students of Medical Informatics as two Different Target Groups

A. Horsch[a], P. Hellerhoff[b], M. Hogg[b], H. Ahlbrink[a], T. Balbacha, T. Liß[a], K. Minov[a], P. Gerhardt[b]

[a]*Department of Medical Statistics, Technical University of Munich, Germany*
[b]*Department of Radiology, Technical University of Munich, Germany*

Abstract

Multimodal diagnostics of gastrointestinal tumours with MRI, CT and video-endoscopy is a rapidly changing domain. The education at our universities should overcome the obstacles of traditional learning based on paper media and oral lectures with retention rates of 10-30% only. The paper presents the objectives and the results of the design phase of the project ODITEB[1] - Open Distributed TExt Book, for Computer-Assisted Instruction in the domain mentioned above. The main objective is to produce an electronic interactive textbook in order to shift education to more efficient learning settings with higher retention rates. The main concepts are 1) three-layer architecture (dynamic case layer, intermediate query layer, static instruction layer) 2) case pool distribution 3) active learners experience (interactive exploration of original image data).

Keywords

Computer Assisted Instruction; Radiology Education; Diagnostic Imaging; Computer Communication Networks

Introduction

Medical knowledge increases rapidly. The call for improvement of teaching level seems justified [8]. Printed books have the disadvantage that the actuality is not very good for domains being under fast development. Multimodal diagnostics of gastrointestinal tumours with MRI, CT and video-endoscopy is such a domain.

In recent years, much progress has been achieved in order to improve diagnostic accuracy by means of medical imaging techniques: Multimodality gives a more complete impression of the tumour, MRI and CT can show the 3D morphology, video-endoscopy gives information about macroscopic features like colour and opacity.

The difficulties of practical multimodal diagnostics are very hard to teach by means of printed media like a book. In general there is only space for one or two "typical" examples for a certain finding. The choice is clear: An author will select an image which demonstrates the pathological alteration even to the inexperienced student. Difficult cases that are hard to read as well as hard to explain to a learning student or colleague are not included.

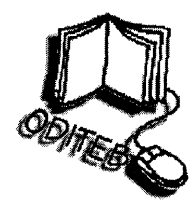

Figure 1 - The ODITEB logo (registration pending)

How valuable for students would also be the possibility of trying out to manipulate images and explore the data by themselves in addition to the didactically prepared lessons. Working with an image, for example optimising its contrast or changing the grey level window, gives much more understanding of the problems of decision making. Retention rates of up to 90% can be achieved by this kind of active learners participation [1].

Last but not least one should improve the interdisciplinary teamwork between physicians and informaticians. The development of sophisticated methods for computer-aided diagnosis (CAD) is more likely to meet the radiologist's requirements if there is a common basis of cases prepared for each of the both target groups, i.e. for doctors and for informaticians.

The increasing number of publications on Computer-Assisted Instruction (CAI) shows a trend to utilise Web-based Internet services to improve education in medicine [1,2,5,6]. The task of designing medical hypermedia is non-trivial and requires a sophisticated analyses of objectives and requirements [7]. The present paper reports the results of this analysis for the Internet textbook ODITEB which is designed to support the education of students of medicine in diagnostics of gastrointestinal tumours and of students of informatics in digital image processing within the same domain. Figure 1 shows the ODITEB logo. We have chosen the book with the computer mouse due to the fact that we adopt valuable concepts of this good old learning medium and embed them into a modern multimedial distributed and dynamic environment.

1. Sponsored by the DFN-Verein, Berlin, with funds of the BMBF (German Ministry of Education, Science, Research and Technology)

Objectives

The strategic aims to which ODITEB wants to contribute are: 1) Improve the quality of education in medicine and medical informatics. 2) Accelerate the knowledge transfer from medical research to patient care.

It is well known, that in traditional classroom settings learners retain approximately 20-30% of what they hear and see [1]. For textual information from a book the retention rate is about 10%. It can be increased essentially by passive learning experiences (up to 50%) and active learners participation (70-90%). In order to shift the classical lecture-driven radiology education in our faculty to interactive experience-driven learning the following objectives have been defined:

1. Provide free-of-charge a high-quality and interactive state-of-the-art textbook in the Internet with a great, continuously increasing variety of up-to-date clinical example cases.
2. Fuse the advantages of existing teaching techniques and media and avoid, as far as possible, their disadvantages.

These objectives have some basic implications on potential solutions: *Free-of-charge* implies utilisation of software that is available more or less freely. *High-quality* implies employment of experts for the medical and informatical texts as well as usage of original image data. Furthermore the didactic quality of cases has to be considered. *State-of-the-art textbook* means incorporation of multimedia in order to illustrate and demonstrate complex matters so that the student can understand them fast and completely.

Material and Methods

Our approach to this task is a Web-based electronic textbook. As basis for a prototype we use the DACHS application [3,4], a distributed medical image management system with Web-interface for administration and usage. It has been implemented by means of WAIS, CGI, PEARL, Apache HTTP-server, IDL (Interactive Data Language) and Netscape HTML-browser. For the final ODITEB implementation, architectures with interoperable Internet added-value services [9] are in the discussion.

The results of the ODITEB design phase have been produced in numerous discussions from January to Mai 1997 with experienced university teachers in radiology and informatics as well as with students in the faculty of medicine of the Technical University of Munich. Concepts of the DACHS application have been incorporated.

Results

Analysis of Learning Media and Educational Settings

In order to get as much benefit as possible from an electronic textbook, the advantages and disadvantages of learning media and educational settings have been analysed. Table 1 shows the result.

Table 1 - Advantages and Disadvantages of teaching techniques and media

Medium or Setting	Advantages	Disadvantages
Printed journal	- Up-to-date - Good availability - Simple to use - Individual usage (time, speed)	- Expensive - Often too specialized - One-sense learning (visual)
Printed book	- Good availability - Simple to use - Individual usage (time, speed) - Comprehensive and detailed	- Time-consuming edition process - No feedback to authors - One-sense learning
Lecture	- Guidance by an expert to what is essential - Multi-sense learning („live") - Some interaction with the lecturer (questions)	- Fixed time window - Fixed speed of lesson - Not detailed
Small group	- Good interaction with the expert - Guidance by the expert - Demonstration of difficult cases - Multi-sense learning	- High costs for large teaching staff - Fixed time window - Nearly fixed speed of course
Learning-by-doing	- Most effective and intensive - Own experience, e. g. interactive image manipulation at a CT console - All-sense learning (= training)	- Prerequisites (preparation with other techniques) - Legal and ethical constraints

The extent to which the advantages can be preserved and how disadvantages can be reduced is summarised in table 2. Obviously an Internet textbook can be considered to join some advantages of all the different techniques, the journal (actuality), the printed book (comprehensiveness), oral lecture (more than one sense), the small group (demonstration of difficult cases) and the learning-by-doing (interactive image processing). Major disadvantage is the missing human-to-human contact (multi-sense or all-sense teaching).

Table 2 - Advantages of an ODITEB-like Internet textbook

Advantage	Technique
High availability	Internet
Individual usage (time and speed)	24 hours per day, 7 days per week service
Comprehensive and detailed	Top experts as authors
Two-sense learning (audio / video)	Multimedia PC Web technology including Java
Demonstration of difficult cases	Large increasing collection of interesting cases from different providers
Interactive image manipulation	Manipulation tools as Java applets
Interaction with the expert	Asynchronous communication between users and authors via email

Table 3 - Disadvantages of an ODITEB-like internet textbook and possible solutions

Disadvantage	Approach to reduce / solve the problem
Complex technology that's difficult to use	Use intuitive widespread standard interface for synergy (Web browser) Provide ergonomic structure and simple navigation features
Time-consuming preparation of cases	Supply a comfortable case authoring tool (case editor)

Requirements

On the background of the results from the previous section we want to give a systematic summary of requirements that should be met by an Internet textbook. There are quite different roles of actors to be taken into account in the scenario of such a textbook. According to these roles the respective requirements are different. We discuss the requirements of users, providers and authors in this section and postpone administrator requirements to the subsection "Components and Actors" of the next section.

User Requirements

Who are the users of our textbook? Students of medicine, students of medical informatics. Students of medicine learn diagnostics of tumours with medical imaging. The other target group gets educated in medical image acquisition and processing. Both groups want to get *(U1) high quality of content.* The material must be correct, up-to-date, evidence-based, relevant and comprehensive. According to the potential of the new medium, the requirement goes beyond the good printed book and comprises the incorporation of still image, video and audio material. The presentation needs to be of *(U2) high didactic quality* and should motivate to work with the medium. Being used to learn with excellent print media, the students, especially medical students not familiar with computers, require comparably *(U3) ease of usage* of the electronic medium. This requirement of user-friendliness is hard to meet, even in our GUI dominated days. In order to enable the student to determine the status of the own knowledge, exercises can be incorporated in printed textbooks. Usually, they consist of questions at the end of each chapter and the correct answers, located on a different place, for example at the end of the book. This leads to the requirement of a *(U4) learning self-control.* As to availability it is important to require *(U5) low or no costs* for the electronic textbook.

Provider Requirements

The main interest of the provider institution is to achieve a benefit for the education of the students. This benefit has two facets: 1) more competent graduates 2) less burdened educational staff. The concrete requirements for the product „electronic textbook" are *(P1) Quality assurance*, for example by an editorial board. The quality is in the focus of interest due to the fact that the institution's reputation highly depends on it. The world wide availability of the information via Internet increases the importance of this requirement. *(P2) Didactic power.* In order to force a measurable impact on the educational outcome it is necessary to achieve an optimal didactic presentation of the contents. The best content is worthless if no student wants to learn it because the presentation is bad and hard to understand. *(P3) Cost efficiency.* The electronic textbook must not cause additional costs in maintenance and usage. *(P4) Ownership of primary* image data. The provider's precious data must be protected against unauthorised usage.

Author Requirements

First of all, an author wants to get support for *(A1)* easy preparation and update of cases. A suitable tool must not only provide an easy generation of correct case data structures. It also has to support the data acquisition phase of this process by bookkeeping features. Next, an author should require a *(A2) Case-specific feedback* or even bi-directional asynchronous interaction with the readers of his case(s) in order to get input for further improvement of the material.

Concepts

ODITEB is not a textbook in the usual sense. Neither it is like a printed book nor it is like an ordinary web-based hypertext application. The main differences are: 1) Openness with respect to authors and case providers 2) Usage of original imaging data 3) Presentation of multimodality diagnostics 4) Addressing of two target groups.

The following subsections present the main ODITEB concepts.

Components and Actors

Before proceeding we completely introduce the logical components of the ODITEB learning scenario (some of them did appear already in the previous section): 1) One *TextBook Server* (TBS) 2) A small number of *TextBook Authors* (TBA), usually one TBA per domain 4) Any number of Case Providers (CP) 3) Any number of *Case Pool Servers* (CPS), in general each CP has one CPS in operation 5) At each provider an arbitrary number of *Case Authors* (CA) 6) A huge number of *Medical Users* (MU), we hope, and 7) A huge number of *Informatics*

Users (IU).

To keep the electronic textbook in operation administrators are needed. The *Textbook Administrator* (TA) is the one who defines which case servers are active components of the ODITEB application. To do this efficiently he needs *(T1) Easy to perform Case Server Management.*

Beside the one TA there are a number of *Case Pool Administrators* (CPA). A CPA is responsible for the management of his provider's case server. To fulfil this task he needs a *(C1) Easy Administration of Authors* and *(C2) Case Server Connection Control.* The latter defines whether the CS is connected to the ODITEB network or not.

Distribution Concept

Figure 2 shows the *Distribution Concept* of ODITEB. As CPs expert radiology centres provide example case data for the textbook. Each CP is a completely independent unit within the scenario. The number of cases stored on its CPS increases dynamically by the outcome of the CAs' work. We call this aspect of distribution the *Case Pool Distribution Concept.* The second aspect of distribution comprises the distribution between instruction part and case part of the textbook. This is explained in more detail in the next subsection.

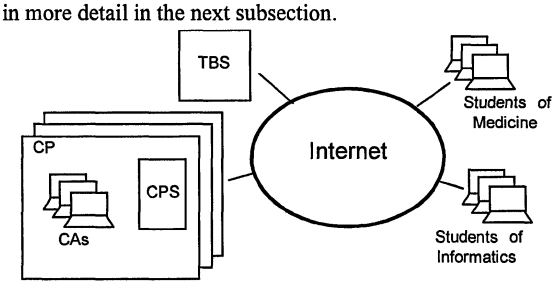

Figure 2 - Distribution of ODITEB

Architecture

The ODITEB textbook is design as a three-layer architecture (see figure 3): The *Case Layer* consists of example cases. This basic layer is distributed over an arbitrary number of providers. Its content is very dynamic. It changes whenever one of the many case authors brings in a new case or updates an existing one. The *Instruction Layer* contains an introduction into the general state-of-the-art radiological knowledge about gastrointestinal tumours and about relevant medical image processing. Its content is comparably static. Once written, it changes in a similar way as (successful) books are reviewed for several editions. The intermediate *Query Layer* connects the Instruction Layer with the Case Layer by means of predefined queries. Every link to example cases, placed by a textbook author in the instruction part of ODITEB, consists of a series of case search attributes. The Query Layer performs the case search when the hyperlink is selected by the learner

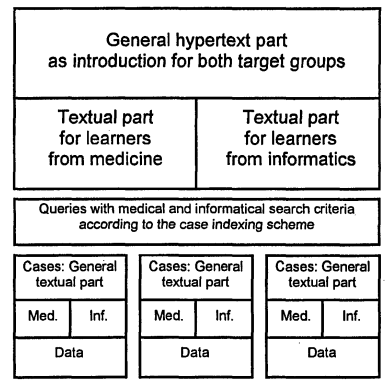

Figure 3 - .Architecture of ODITEB

The instruction layer as well as all elements (cases) of the case layer consist of a general part addressing both students of medicine and students of informatics, and two separate parts with specific learning material addressing only one group, each.

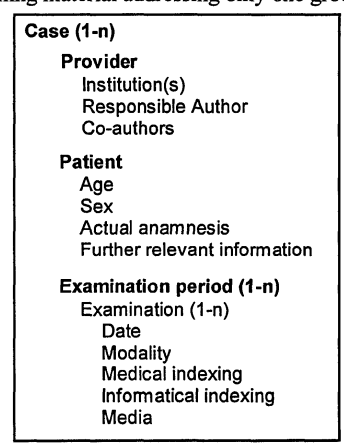

Figure 4 - The ODITEB Case Format

Case format

In order to provide an efficient standardised submission procedure for CAs, the ODITEB Case Format (OCF) has been defined. Figure 4 shows the rough logical structure of the format. Each ODITEB case consists of at least 3 items. The "Provider" item contains information about the provider institution and the author(s) of the case. The "Patient" item contains minimal data about the patient. These data (age, sex, actual anamnesis) are important from the learning point of view, but they must not create the possibility to determine the patient's identity. (What do You think about a female patient of 107 years, with a certain anamnesis, living in a small town, where people believe to know something about the diseases of a very old neighbour?). The CA is responsible for anonymity of the case data he provides to ODITEB. An "Examination period" item contains all original data and the didactical material (annotations, graphical overlays, voice clips etc.) of the examinations performed for one diagnostic decision making task utilising different imaging modalities.

Content Structure and Navigation

Following an intuitive and simple philosophy the content of ODITEB will be clearly structured like a conventional book with introduction, parts (medicine and informatics), chapters and sections. Figure 5 shows this structure with the parts "Medicine" and "Informatics", the medical sections "Oesophagus", "Stomach" and "Rectum", the informatical sections "Preprocessing", "Object Detection" and "Classification". The "Agreement" at top of the hierarchy contains the important hint for all users, that the ODITEB textbook addresses professionals and is not made for public use (some of the material, especially films from video-endoscopy, maybe rather hard stuff for many people).

As navigation elements we will incorporate: *Home* (go back to ODITEB Homepage), *Up* (go to the index page one level above the actual position), *Next Section* (go to the next section in sequential book order, i. e. the right neighbour node in the tree structure of the book), *Previous Section* (left neighbour in the tree structure).

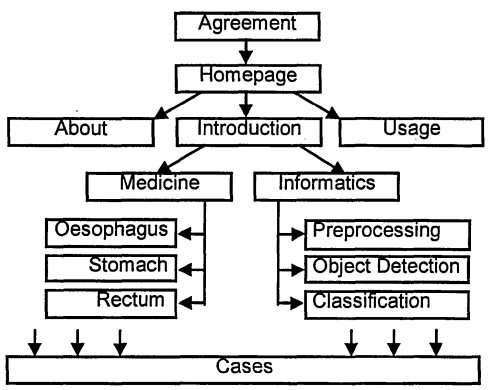

Figure 5 - ODITEB Content Structure

Discussion

The concepts presented provide a very flexible and mighty framework for an evolutionary development of CAI applications. The work can start with just one provider and a comparably small number of cases (has been finished as ODITEB prototype in October 1997). Then the scenario can be easily extended by further providers and their cases. This is planned for the first half of 1998 with radiological partners at the universities of Erlangen-Nürnberg and Würzburg.

The well-defined case format and the use of original image data leave many possibilities open for future extensions of the learning setting.

References

[1] Dounavis P, Karistinou E, Diomidus Marianna, Mantas J. Using World Wide Web technology for educating Students in the Health Care Sector. In: Pappas C, Maglavera N, Scherrer J-R, eds. *Medical Informatics Europe '97.* Amsterdam: IOS Press, 1997; pp. 686-690

[2] Downie AC. Teaching radiology on the Internet. *Clin Radiol* 1997: 52 (1):4-7

[3] Findling A, Horsch A, Zink A (1997) An Open Distributed Medical Image and Signal Data Server Network with World Wide Web Front-End. In: Pappas C, Maglavera N, Scherrer J-R, eds. *Medical Informatics Europe '97.* Amsterdam: IOS Press, 1997; pp. 591-595

[4] Horsch A, Findling A, Riescher H, Zink A (1997) An Approach to Medical Collaboration Networks, In: Muche R, Büchele G, Harder D, Gaus W (eds): Medizinische Informatik, Biometrie und Epidemiologie GMDS '97, MMV Verlag, München, 1997, S. 236-239

[5] Partovi S. RIP: Radiology Internet Protocol. *Radiographics* 1996: 16 (6): 1495-501

[6] Scalzetti EM. Radiology teaching-file cases on the World-Wide Web: a second-generation viewer. *Am J Roentgenol* 1997: 168 (3):615-7

[7] Soula G, Delquié P, Vitton O, Bartoli JM, Fieschi M. Designing medical hypermedia: the FORUM project. In: Pappas C, Maglavera N, Scherrer J-R, eds. *Medical Informatics Europe '97.* Amsterdam: IOS Press, 1997; pp. 712-716

[8] Wu E, Lian Z. Raise the teaching and research level to fit development of diagnostic imageology. *Chin Med J Engl* 1996: 109 (1): 62-4

[9] Zabulis X, Chronaki C, Orphanoudakis S. The *I²Cnet* Service Architecture Paradigm. In: Pappas C, Maglavera N, Scherrer J-R, eds. *Medical Informatics Europe '97.* Amsterdam: IOS Press, 1997; pp. 596-600

Address for correspondence

Dr. rer. nat. Alexander Horsch
Institut für Medizinische Statistik und Epidemiologie
Technische Universität München
Ismaninger Str. 22, D-81675 München, Germany
Email alexander.horsch@imse.med.tu-muenchen.de
Web http://www.imse.med.tu-muenchen.de/mi/