A Hypermedia Tutorial for Cross-Sectional Anatomy: HyperMed

Abstract
Modern imaging techniques like computer tomography (CT) and nuclear magnetic resonance (MR) imaging have become essential in clinical diagnostics and also in teaching gross anatomy to medical students. As a consequence, special classes in (cross-)sectional anatomy are being added to the curriculum in many anatomical institutions. Since institutional budgets often do not allow extensive supervision beyond the very limited time frame of traditional courses in gross anatomy, a computer-based hypermedia tutorial (HyperMed) was created and integrated into the teaching program of the Institute of Anatomy at Essen University. HyperMed offers two components, one for authors (e.g. teachers who can customize the contents of the program) and a second for users (e.g. students). In the present version, digital cross-sectional human images have been edited. The relevant anatomical structures in these images have been marked, named, and linked to additional information and figures (in particular schematic figures and CT images). Users can obtain information at different levels: (1) index-based retrieval, (2) navigational retrieval (on inspecting cross-sectional images the user is asked to identify structures) and (3) a history list enabling users to go back to any previous point of navigation. HyperMed was first tested in the winter terms 1995/1996 and 1996/1997 during classes on cross-sectional anatomy which are a supplement to the traditional dissection course of the Institute of Anatomy, University Essen. It was well received by the students who found it a helpful adjunct to learning cross-sectional anatomy.

Introduction
Modern imaging techniques like computer tomography (CT) and nuclear magnetic resonance imaging (MRI) have become indispensable in clinical diagnosis and, therefore, these images are finding their way into the gross anatomy curriculum for medical students. Students should be trained as early as possible to transpose their knowledge of three-dimensional anatomy, acquired in traditional dissection...
courses, to interpretation of two-dimensional, sectional CT or MR images.

In order to prepare medical students for this task we have integrated supplementary study sessions in cross-sectional anatomy into the traditional dissection course for several years. Students are introduced to cross-sectional anatomy by student tutors in five 2-hour sessions, each corresponding to the different sections of the overall dissection course. In these classes, students study real sections (1.5 cm in thickness) obtained from formalin-preserved human bodies sealed in lucite cuvettes as described by Hohn et al. [1995] and Post et al. [1996]. It was very helpful to students to use real sections because they compare very well to the dissected bodies with respect to colors and proportions and retain a certain degree of three-dimensional appearance because of their thickness. These sections are studied with the help of standard anatomical atlases and, in particular, cross-sectional atlases like Ellis et al. [1991] or Romrell et al. [1996]. They are also compared with CT images, schemes, and anatomical models in order to facilitate understanding to two-dimensional representations of human anatomy. After course hours students have free access to the sections. However, supervision by faculty or tutors is limited to the time of the official classes. Since students feel a definite need for intensive instruction (due to difficulty of the subject, labels missing on the sections, sectional images being subjects of exams) we prepared a supplement to the course material which is a computer-based tutorial for cross-sectional anatomy.

Our concept was to develop a program that would meet the following requirements. (1) The program should serve as an introductory tutorial for cross-sectional anatomy for first/second-year medical students. (2) The system should be an interactive atlas of sectional anatomy that would also offer the guidance of a tutor. (3) Users should become acquainted with the program by intuitive learning at the computer without supervision. (4) Hardware requirements should be compatible with student budgets.

The program that we developed, HyperMed, is a hypermedia system allowing authors to create hypermedia documents accessible to users by different ways of unrestricted navigation. Its content is, like all hypermedia documents, constructed as a nonlinear series of computer files consisting of logical units, called nodes, which are interconnected by links. A node may contain any kind of information, e.g. text, graphics, etc. The software design phase was started in spring 1995 and lasted about 6 months. The first version of the program called HyperMed Version 1.01 was used during the supplementary course in cross-sectional anatomy in the winter terms 1995/1996 and 1996/1997.

Materials and Methods

The process of software development is communicated in a separate publication by Tochtermann et al. [1996]. Here we report on how the material presented by HyperMed was organized and how students use this program. HyperMed, generally, distinguishes between authors (e.g. anatomists or more generally teachers) and users (e.g. students). In addition to the original authors (who developed the program) any teacher (now also acting as an author) will be able to add further files in order to meet individual requirements. In HyperMed, the material is available to users via a standard mouse-directed graphical user interface (see below).

Hardware

HyperMed is operated on personal computers under the Windows 95TM operating system (Windows 95TM is a trademark of Microsoft Corporation). Computers used for creating and testing the courseware were equipped with an Intel PentiumTM 90 MHz, a minimum RAM of 16 megabyte (MB; standard systems for classroom use had 32 MB RAM), and a graphics adapter board with 2 MB of video memory (which is mandatory for the program in its present form). Seventeen-inch monitors were used. Images were scanned on a Hewlett Packard ScanJet IIX.

Software

HyperMed was developed with the compiler Visual C++ Version 2 from Microsoft. This compiler produces a very fast 32-bit code and offers a much higher level of flexibility as compared to authoring systems like ToolbookTM (Asymetrix) or DirectorTM (Macromedia). The authoring component of HyperMed contains a special graphic editor, "mmeditor.exe", that can be used to mark irregular structures in images by freehand drawings (rather than being restricted to a limited number of geometrical shapes). HyperMed, thereby, provides a simple way to link irregular structures in an image to other nodes. In addition we have implemented our own fast viewer part for JPEG images in order to keep loading times for images as low as possible [Trzcicki, 1996].

Images

Color photographs of formalin-preserved cross sections mounted in lucite cuvettes were taken from the inferior/distal side of these sections, corresponding to the standard orientation of CT images. These photographs were digitized with the scanner set at 16.7 million colors (24 bit) at 1,800 by 1,200 pixel resolution. The original graphic file size of up to 7 MB was reduced to about 300 KB by compression (JPEG) without significant loss in quality. Illustrations from anatomy textbooks and atlases were also integrated into the system as were topographical schemes of organs and blood vessels, radiological images and CTs. If necessary, the size and the colors of images were corrected after scanning using common graphic programs like Corel Photo-PaintTM (Corel).

Editing of Images

In order to enable interactive use of images, structures/organs were marked with fluorescent green outlines using a "mmeditor.exe" (see above) with several standard two-dimensional graphic tools. Defined shapes were circles, rectangles, polygons or ellipses. Irregular contours could be edged by freehand drawing with precision to the pixel. Each area that had been marked was used as an anchor for a link to the anatomical name of the structure that was outlined. The anatomical
name describing each structure was automatically added to an index. In this way, up to 50 structures were marked in the image of each body section. Identifying all structures in a section and editing the image as described above could be finished by an experienced student helper within about 4 h. Editing also involved attributing a different cursor design to all structures that had been marked. All structures that may be highlighted are indicated when the cursor is moved across. Crossing selectable structures the cursor turns from 'o' to '+' . The outlines of structures can be highlighted individually at any time by clicking with the mouse within the borders.

Textware
Anatomical names were linked to structures marked in the images as well as to additional text nodes. Both, anatomical names and text documents, were authored with the Windows 95 editor. The nomenclature used conforms primarily to the current edition of Nomina Anatomica, but clinical and colloquial synonyms were also added to the index. Synonyms were linked in the index thereby connecting them to the proper anatomical term marking each structure, ensuring that synonyms could be used interchangeably. In the texts (not in the list of anatomical names), certain terms were highlighted as 'hyperlinks'. These hyperlink terms were added to the index where authors established and still could create links with other index terms, with text documents or with structures in images. Other links were established between (1) different structures in an image or between the same structures found in several images, (2) different structures in an image belonging to a group (e.g. all parts of the digestive tract in an image may be grouped) as well as (3) groups within a particular image and in different images. For (2) and (3), the author had to describe the group by an anatomical term and add this to the index. Terms that are highlighted in texts, therefore, link the user to other information which is shown after clicking on the highlighted term. Terms that are written in green are linked to structures marked within (single or several) images, while clicking on terms in blue can open text and/or graphic documents with additional information (appearing in the image and/or text window) on the respective context.

Results

User Interface
HyperMed offers a Windows 95 graphical user interface. A screenshot of this interface is shown in figure 1. Because a majority of prospective users of HyperMed can be expected to have worked with computer programs under Windows™ (trademark of Microsoft Corporation) before, they are usually familiar with this type of interface. All essential functions are directed with the mouse resulting in a simple handling of HyperMed.

The user interface of HyperMed is constructed from different windows, the central one being the ‘image window’ (1 in fig. 1). After loading an image, part of it will fill this window at 0.5× magnification. However, its magnification can be changed to 0.33×, 1×, 2×, 3×, 4×, and 5× with the ‘Zoom’ arrows in the upper left corner of the window. At higher magnifications, the visible portion of the image can be scrolled by clicking on the scroll bar arrows on the right and bottom of the window. From any magnification the user may go back to the overview aspect of an image by clicking on ‘Übersicht’ (overview) on the upper left side of the window. Optionally, images may be expanded to the full size of the screen (available from the context menu, see below).

The image that will appear in the image window is selected in the ‘section selection window’ on the right side of the image window (2 in fig. 1). The section selection window shows a ‘scout’ in which horizontal dotted lines indicate the planes of the available sections. A section to be loaded into the image window is selected by clicking on the respective line which then turns to a solid blue line. The selected plane can also be shifted by the arrow buttons at the bottom of the window. The image will be loaded after clicking the ok button in this window. Alternatively double-clicking on a dotted line or on the solid line will cause the respective image to be loaded. The left button at the bottom toggles between female and male body sections. In addition to the solid blue line the identity of a section is specified at the top of the window: ‘Schnitt M14’ means section No. 14 of the male body. In figure 1 the section selection box is set to load horizontal sections from a male trunk.

Loading the image generally calls up a text which is linked to this image and will appear in the ‘text window’ in the lower part of the display (3 in fig. 1). Using the scroll bar on the right side of this window users can read through all parts of the text. Three different sizes can be chosen (under ‘Schriftgröße’ in the main menu bar at the top of the screen, 4 in fig. 1) for the letters in order to facilitate reading from a distance. The text window first displays a text introducing the respective section/image and directing the attention to the relevant structures. In the texts, some words or terms are written in green letters. These (usually anatomical names) are linked to structures in the corresponding image and after clicking on them the outline of the respective structure is highlighted on the display (5 in fig.1). Other terms written in blue (see fig.2) lead to further textual and/or graphical information.

On the left side of the image window a column of six buttons offers different functions (6 in fig. 1). Clicking on the top button displays the ‘index window’ in place of the section selection window (see below). The second button reactivates the image of the cadaver section after a CT image, MRI, or a schematic illustration (corresponding and linked to the real section) has been loaded. A red diagonal bar across these buttons indicates that the respective option is not available for a certain sectional plane. The help button (Hilfe) opens special pages containing texts and screen shots on how to operate the program.
The ‘history box’ which records each move of the user during a session is found on the left side of the text window (7 in fig. 1, 3 in fig. 3). Using the different arrows at the top of the box or by double-clicking on any of the terms listed the user can (sequentially or in one step) go back to any previous station of his session and reload the information he was using.

Working with the Image Window
When the concept for HyperMed was developed it appeared important to define a quick, unequivocal, and interactive way of identifying and naming anatomical structures in the images on the display. In addition to giving the proper designation for a structure, the so-called ‘context menu’ (1 in fig. 2) plays an essential role in linking individual pieces of information. Dragging the mouse will move the cursor across the screen. In the image window it will change from an arrow to ‘+’ or ‘−’. Whenever the cursor hits a structure that has been marked and given a name by the author the cursor will turn from ‘−’ to ‘+’. After activating a structure in an image by clicking on it, it will be outlined in green. Now, clicking the right-hand mouse switch will call up the context menu that provides the name of the structure (1 in fig. 2). Furthermore, the context menu offers links to additional information. For example, the left ventricle (fig. 2) of the heart has been identified and – as

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**Fig. 1.** Overview of the user interface of HyperMed. 1 = Image window displaying a section from a lower thoracic plane; 2 = section selection window (will be switched to the index window by clicking on the top selection button); 3 = text window; 4 = main menu bar; 5 = clicking on the term ‘Zwerchfellkuppeln’ in green lettering will outline the respective structures in the image window; 6 = column of six buttons for different selections; 7 = history box.
Fig. 2. The context menu is activated by clicking on a structure within the image window (here the left ventricle of the heart). The context menu will then provide the anatomical name for the structure (1). In addition the context menu provides links to more information (2).

supplementary information – the context menu presents a link to an overview of the heart (2 in fig.2). This hint is not only linked to the particular image shown on the display but also to all related structures in other images (available from the 'index window', see below). When another image containing the highlighted structure is loaded by the user the respective structure is outlined automatically. The number and kind of references/links that are given for a structure in the context menu can be precisely defined by an author. From the context menu a user can also highlight or list all structures in an image. In the latter case, listed structures may be activated by clicking on the term in the list.

Another way of navigation is shown in figure 3. Clicking on the top button on the left side of the screen (1 in fig.3) switches the section selection window to the 'index window' (2 in fig.3). In this box, the user may look for defined pages containing information. The index window automatically color-marks the topic (i.e. the title) of the actual text window, e.g., ureter overview (= 'Ureter-Übersicht') in figure 3. If a term in the index is linked to a structure marked in an image, HyperMed will list all images containing this structure in a separate window which is activated by double-clicking on the index term. The user can then select any of these images and HyperMed will highlight the respective structure after loading the image. In addition, users
Fig. 3. The index window (2) may be called up by pushing the top selection button (1). This window will automatically go to the position in the index of the title of the text window and highlight it. At the top of the window users can type in terms for searching the index. The index window will automatically move to the correct position of the index list. If an appropriate section is displayed the structure corresponding to the search term will also be outlined. When the index window is selected the top selection button shows the symbol of the section selection window; clicking on this button will now switch the index window back to the section selection window. In this example, this step (to the 'Ureter-Übersicht' page) was recorded automatically by the history box (3) [X-ray from Kriz, 1994, with permission of Urban & Schwarzenberg].

can type search terms in the upper bar of the index window (2 in fig. 3) and the window will automatically move to the correct position of the index.

Working with the Text Window
The entire text material is constructed as a hypermedia document in which all text nodes have a uniform layout (see 3 in fig. 1). Each text (i.e. each node) has a title heading which is also listed in the index and when used will be recorded in the history box. Colored words represent links to other nodes.

The main texts are supposed to have different functions. They introduce the user to an image, starting with the most important structures (see 3 in fig 1) and providing an overview for, e.g., the section shown in the image window. The names of such structures are green in the text and after clicking on them the corresponding structure is outlined in the image window. Green text indicates links either to in-
vidual structures or to groups of structures that belong to a system like the parts of the digestive tract. In addition to terms in green others appear in blue lettering. The blue text provides links to additional textual or graphic information.

In front of the main text, the title of the text window may be followed first by terms in blue which integrate the particular contents into a hierarchical context. In figure 3, for example, such links connect the ‘ureter’ with the urogenital system (Urogenitalsystem-Übersicht) or with the retroperitoneal space (Retroperitonealraum-Übersicht). At the end of the main text, the user finds a list of links to related information on the same or on a lower hierarchical level. At the end of a text document that is attributed to an image the user finds a list of all structures in the image that have been marked by the authors and that the user should have noticed. This list is thought to be helpful for students preparing for a test.

Some nodes containing additional textual or graphic information are not necessarily represented by colored terms in the text window. The title terms of such nodes are found in the index window such as general texts and schematic overview graphs for the system of blood vessels, for the peripheral nerves, the urogenital system, or the digestive tract. Such additional information is included in order to help understand the sectional images in the program.

Additional Functions

HyperMed has a list of synonyms for anatomical terms that helps locate structures with the index menu, even when colloquial names or abbreviations are used synonymously, such as Arteria lienalis, A. lienalis, Arteria splenica, as well as splenic artery.

On classroom computers each user can access HyperMed only with a specific, but anonymous password. This enables the program to create an individual record for each action of every user. As a result authors/teachers can perform statistics on how frequently any component of HyperMed is used in general or how different groups of users approach a task. These records can be accessed by users in order to see how much of the whole information offered by the system they have seen/learned at the moment.

Acceptance by Students

HyperMed was used for supplementary classes in cross-sectional anatomy during the dissection course from the winter term 1995/1996 on. The program was offered in parallel with the real sections that were displayed in the classroom and explained during classes. While tutors were available only during the very limited class hours (five sessions of 2 h each for each student), students had free access to four computers.

A survey revealed that of the approximately 160 students about 30% owned a private computer or at least had constant access to a computer. However, most of them had not come across instructional software before. Those students who were familiar with computers usually were very positive about using HyperMed as were also about half of the students who had not used computers before. The other half used the program only occasionally, if at all, and preferred to stick to the traditional way of interpreting the real sections with the aid of anatomical and cross-sectional atlases. Usually, students used HyperMed in groups of three to five communicating with each other as well as with the program. At times, particularly shortly before exams, the four computers available were overcrowded and were considered insufficient for all students.

Most students found the user interface of the program well-organized and intuitive. Even novices usually became familiar with the program after 20 min. Interestingly, after a while many students did not use the real sections anymore after they had experienced the high resolution of the images on the display. The features of HyperMed that were found very helpful were (1) the outlining of structures (not used in most anatomical atlases where structures and their anatomical names are connected by lines), (2) the introductory texts linked to the images as well as the direct links to additional text and graphic information, and (3) the high resolution of the images, and the ease of handling provided by the organization of the user interface. As an improvement for HyperMed, students suggested a self-test examination mode.

Discussion

Courses in sectional anatomy are becoming increasingly important in teaching gross anatomy, but often cannot be covered sufficiently by faculty or tutorial supervision. Therefore, we developed a computer-based hypermedia tutorial under Windows 95 for sectional anatomy, HyperMed, which is based on real sections from human bodies that had been used for several years as a supplement to the traditional dissection course [Hohn et al., 1995; Post et al., 1996]. The program intends to introduce first/second-year medical students participating in the dissection course to the complex matter of cross-sectional anatomy in order to prepare them for interpreting radiological images. The program does not intend to provide a comprehensive course of radiological anatomy.

The concept of HyperMed was inspired by the functionality of internet browsers for the WorldWideWeb (WWW)
and by the concept discussed by Cimino et al. [1992]. The philosophy behind using Visual C++ for software development was to design a flexible framework for a number of different applications. HyperMed is subdivided into a number of independent but well-interacting software components. The basic idea for this approach came from the area of component software development. The viewer part for JPEG is consequently not only usable directly within HyperMed but also for different other software systems that can even be developed by a third party. On the other hand, if the compression technique is improved, e.g. by incorporating fractal image compression techniques, substitution of the JPEG viewer part will not affect the other components and the functionality of HyperMed. This advantage is not offered by Toolbook or other authoring tools. Therefore, further improvement of HyperMed by incorporating the latest technology will be an easy task. While other systems have to be maintained by the original programmer, even other software developers will be able to extend HyperMed, once knowing the interface protocol of the different interacting components. The contents of HyperMed are composed of many graphic nodes (real cross-sectional images, CTs, MRs, and schematics) as well as a lot of text nodes. The program can not only be used as a supplement to traditional classes in sectional anatomy but also as a stand-alone tutorial given its high image resolution. While the original version described here is in German, it can easily be translated into other languages. This is facilitated particularly by the fact that all text elements are stored program-independently within files that can be modified with different standard text editors. A translation can thus be done easily by any author, i.e., not only by the original developers.

Before we decided to develop HyperMed we intended to use some of the already existing programs that were available, but different drawbacks prohibited this attempt. The most common disadvantage appeared to be the fact that the content of programs did not quite correspond to the courses established at this university. But there were also operational problems. The program 'ADAM' (ADAM Animated Dissection of Anatomy for Medicine, ADAM is a registered trademark of ADAM Software, Marietta, Ga., USA, Copyright 1996) may be understood as a computerized, interactive schematic atlas of human anatomy. It does not contain any images obtained from real preparations, only schematics. Very few cross sections which are also schematic are matched with variably corresponding radiological images. As in HyperMed, structures can be selected and activated by mouse click without limitations. ADAM like HyperMed offers very extensive authoring facilities making this program an excellent tool for preparing lectures and seminars. In HyperMed, however, the context menu together with links available from within the text window integrates the structures of a section/image into informational contexts much better because users can obtain additional information without leaving the sectional image they are studying.

VOXEL MAN [Höhne, 1995] presents very impressive and useful three-dimensional images for neuroanatomy. Recent versions also incorporate the Visible Human data (see below) including three-dimensional reconstructions and also detailed interpretation. The program requires graphic workstations that may be too expensive for the average user. Furthermore, the program offers only limited individual authoring by teaching staff.

The AnaTuTutor was introduced by Niemeyer et al. [1992] with a component for histology and a second one for anatomy. In this program, cross-sectional anatomy is not available. The histology component is based on MS-DOS and has become available commercially in the meantime [Niemeyer et al., 1994]. The anatomy component of the AnaTuTutor is still being developed and provides a guide/instructions for the dissection course (accompanied by additional information). Like HyperMed, it is based on images and hypertext operated under Windows™ versions (not Windows 95). Unfortunately, however, this MakroTutor is structured according to the local dissection program at the Tübingen University insofar as the individual steps of dissection that have to be done by a student on a given day are described. In contrast, HyperMed can be used for courses in sectional anatomy at any location and (because of the high resolution of the images) even without the original real sections that we simultaneously display to the students.

The ANATOM-Tutor [Beaumont, 1994] represents an intelligent tutoring system based on user models capable of learning while being used. At the present time it is limited to a small proportion of neuroanatomy.

An excellent data set of cross-sectional anatomy has been prepared by the National Library of Medicine (NLM, USA) as a part of the 'Visible Human Project' [Ackerman, 1992, see also internet address http://www.nlm.nih.gov/research/visible/visible_human.html]. Cross sections of complete human bodies at a thickness of 1 mm for the male and 0.3 mm for the female have been digitized resulting in a huge database of cross-sectional images associated with corresponding CT and MRI images. It is often considered an advantage of these sections that they present fresh tissue colors since they originate from nonpreserved (fresh frozen) cadavers. However, the colors do not compare to the
colors of formalin-preserved cadavers as used in the dissection course. Interpretation of images of formalin-preserved sections as used in HyperMed is, in our experience, much easier for first-year medical students than the ‘life-like’ colored images of the Visible Human since their colors closely resemble those students are used to see in the dissection laboratory. An advantage of the Visible Human Project data as compared to HyperMed may be seen in the near-perfect morphological match of fresh tissue, CT, and MR images facilitating a direct comparison. In contrast, the mismatch between outlines of many structures in all modalities in HyperMed (due to differing sources for sections, CT, and MR images) may prepare students better for interpreting the vast structure diversity of radiological images from patients.

Another disadvantage that we feel the Visible Human images have as compared to the sections used in HyperMed is the lack of a third dimension. In our teaching of the introductory courses it appeared helpful that a certain degree of three-dimensionality can still be recognized in the sections of 1.5-cm thickness used in our case [discussed in Post et al., 1996]. Furthermore the data of the Visible Human Project lack any textual explanations. They cannot be used easily in teaching first-year medical students without extensive editing after a critical selection of appropriate sections. This drawback also applies to most of the Visible Human Data available on commercial CD-ROMs. A complete list can be obtained from the internet address http://www.nlm.nih.gov/research/visible/human.html. Only two of the programs listed there, ‘Beyond Vesalius’ [Nieder and Nagy, 1996] and ‘Cross-Sectional Anatomy Tutor’ [Bouvier et al., 1996], are interactive tutorial-type programs that are – like HyperMed – suitable for first/second-year medical students, including interpretations of structures and additional information. Both of them have the advantages but also drawbacks discussed above. A general disadvantage appears to us to be the fact that the terminology does not meet international requirements by using the current version of Nomina Anatomica. ‘Beyond Vesalius’ presents complete labeling of a set of selected structures but not individual labeling of single structures. Labels are connected with structures by lines while exact outlines of structures are not highlighted as in HyperMed. The latter is provided by the Cross-Sectional Anatomy Tutor which, however, appears not to offer intensive tutorial guidance for beginners like HyperMed and may be better suited for advanced medical students. For a further development of HyperMed, we plan to include images from the Visible Human Project (fresh tissue sections as well as CT and MRI images) in order to offer this option.

A concept similar to the Visible Human Project was followed by Hillen [1993–1995] for parts of the head and neck region. This series of very limited material combines real sections, CT images and histological sections including interpretations. Some other programs provide more comprehensive cross-sectional anatomy but only as CT images [Küper, 1994; Wegener, 1995; Weir and Abrahams, 1995; Grunewald et al., 1996].

The ‘Digital Anatomist Browser’ is based on the Unified Medical Language System (UMLS) of the NLM [Brinkley et al., 1993]. This appears to be an interesting approach to standardizing the retrieval of anatomical information which may also be considered for integration into HyperMed. The Digital Anatomist Browser provides predominantly images of neuroanatomy and some limited material on the heart and the mediastinum (real sections as well as correlated schematics, three-dimensional models, and Quicktime animations, but no function for three-dimensional manipulation as in VOXEL MAN). It appears, however, not to offer a guided tutorial for sectional anatomy as HyperMed does.

All programs that have been discussed above (like ADAM or VOXEL MAN) have the disadvantage that further modifications, improvements and adaptation to different local situations can apparently only be made by the developers of these systems. In contrast, HyperMed was designed so that single components can be exchanged by other authors (teachers) once obtaining the specifications of the interfaces used by HyperMed.

Further development of HyperMed will be decisively influenced by the experience obtained during classroom work, by communicating with our student users, and by the statistical evaluation of the information on user sessions that is automatically recorded by the program as well as from the evaluation of questionnaires filled out by users. HyperMed may also provide a basic program to be extended for teaching advanced anatomy courses, e.g. courses for training radiologists in diagnostic imaging. With the many possible uses of computer software programs in the clinic and advanced courses it is important to introduce the medical students to them at a very early stage of their studies.

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References


