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Synopsis

Education

Computers have been used for medical education from the beginning, since it was recognized early on that the computer could dynamically lead the student through a subject area in ways that a static textbook could never do [1].

Early systems were primarily text based, accessed through a terminal connected to a time-sharing system. Although these systems were often very useful for learning aspects of clinical medicine, their use was limited to large institutions with the requisite hardware. In recent years the advent of low cost graphically-based computers, together with commercial authoring tools, have led to a large number of medical CAI programs, of which the four in this section are examples.

The four examples illustrate two basic themes in medical CAI: evaluation and new capabilities. The first two papers deal primarily with evaluation of commonly available methodology [2,3], whereas the second two demonstrate advanced capabilities that are not yet widely available [4,5].

The need for evaluation arises in CAI, as it does in all medical informatics domains. As more CAI programs are produced they tend to divert resources from traditional teaching methods and, in fact, some of the commercial programs, although very promising educational tools tend to be quite expensive for the individual user [6]. The question must then be asked: do these programs actually increase the ability of the student to learn, over a more traditional and less costly approach? Or, if students prefer these systems, do they at least do as well as traditional approaches? The first two papers address these questions.

The first paper, *Educational efficacy of computer-assisted instruction with interactive videodisc in radiology*, is by Chew and Smirniotopoulos [2]. Their CAI program, which is used to teach common radiologic problems to medical students and residents, is typical of many programs that use Macintosh Hypercard to control an attached video disc. However, unlike most similar programs, the authors performed a controlled evaluation of the efficacy of the CAI program for learning radiologic concepts.

In the evaluation an identical test was given both before and after medical students were exposed to the learning materials. The students were divided into three groups: a control group that was assigned no extra materials, a group assigned the radiology textbook from which many of the video disc images were drawn, and a group assigned the CAI-video disc. Results showed that test scores for the control group did not significantly increase over the period of the evaluation, whereas those for the CAI group and the textbook group did increase significantly; there was no difference between the CAI and textbook groups. In addition, surveys indicated that the students preferred the CAI methods over other methods. Similar results were obtained for a group of radiology residents, although in this case the control group was self-selected to be those who decided not to use the CAI approach, a difficulty the authors point out in their discussion.

The second paper, by Lonwe and Heijl, is called *Computer-assisted instruction in emergency ophthalmological care* [3]. Their program, which uses Hypercard without a video disc, teaches ophthalmology patient management through simulated cases, with branch points determined by the students' responses.

The evaluation of this program was designed to answer three questions: (1) does the use of the CAI program increase knowledge in emergency ophthalmological care beyond that obtained with traditional teaching? (2) could CAI be used as a substitute for some parts of traditional instruction? and (3) do students prefer this method over traditional methods? By using an experimental design in which different classes of students served as their own controls, the authors were able to answer all three questions affirmatively. An additional question that comes to mind is, does the knowledge gained by CAI remain with the student as long as it does using conventional methods? Since in this study the students were apparently tested immediately after they were exposed to CAI, it is not clear how long the knowledge remains with them.

The results from both of the first two papers suggest that CAI is as good as traditional methods of learning for at least some areas of the curriculum, and that students usually prefer this method. However, although the results by Lonwe and Heijl [3] suggest that CAI can improve learning over traditional methods, other studies, including that by Chew and Smirniotopoulos [2] do not show a clear superiority of CAI over less expensive textbooks in their ability to teach.

One reason given for the lack of demonstrated improvement is that most CAI programs simply re-package the information that is already present in textbooks. The last two papers in this section describe capabilities that are not available in any textbook.

The third paper, by Narayan et al. [4], is called*Animated visualization of a high- resolution color three dimensional digital computer model of the whole human head.* The premise of this and the fourth paper is that 3-D animated visualizations of human brain anatomy can greatly aid in the comprehension of complex 3-D anatomical relationships. The paper by Narayan et al. describes methodology used to section and photograph a human brain, then to digitize and visualize these, as well as MR and CT sections, using volume visualization and surface rendering software on a graphics workstation. Animated sequences of rapid 2-D slices through the volume dataset, as well as 3-D rotations of brain anatomy, were recorded on a video disk. The video disk was interfaced to a Microsoft Windows program that asks questions about the content of various animation sequences. Although no formal evaluation of this program is presented, it represents a new capability for CAI that is not available in textbooks. Once digitized images of the whole human body become widely available as a result of the Visible Human Project [7], many more examples of this kind of program will be developed.

The final paper, by Tiede et al. [5], is entitled *A computerized three-dimensional atlas of the human skull and brain.* This paper demonstrates the most advanced technological capabilities of any of the papers in this section, capabilities that are not feasible for today's personal computers, but which will become commonplace as the power of desktop computers continues to increase.

The system described by Tiede et al. uses a very simple but elegant data structure, which is an extension of the standard 3-D voxel data structure used to represent MRI or CT volumes. In the standard data structure, each of the individual volume elements, or voxels, is represented by a number describing the image intensity at a given 3-D location in the image volume. Given this representation, visualization techniques can be used to derive arbitrarily oriented 2-D slices through the volume, or to generate 3-D renderings. In the extended data structure information is added to each voxel which denotes, among other things, the name of the structure represented by the voxel. This additional information allows the visualization software to automatically label any part of the rendered image, to supply the name of the structure in response to a mouse click, or to remove from the image all voxels labeled with structures chosen by the user. These capabilities allow the system to simulate dissections or surgical operations in arbitrary ways that are not pre-programmed as they are on the video disk systems.

Such capabilities do not come without a price, as the authors point out. A significant amount of time is required for an anatomist to label all the voxels, and the image operations are not fast enough on current hardware. However, once the images have been labeled they can be manipulated in arbitrary ways, and hardware improvements should speed up the generation of images.

Even with advances in computer hardware, it will be several years before the power of a system like that described will be available on a low-cost desktop. An interim solution might use the emerging "Information Superhighway" to generate the images on high-performance supercomputers in response to user requests, and then download them to a low-cost PC or Mac [8,9] without the user necessarily having to know that the images were generated at a remote location.

An additional advantage of such an approach is that it would allow the information, which is now "locked up" in all four of these stand-alone programs, to be accessed by many other programs distributed around the expanding health information network.

As the four examples in this section show, there is a wide range of educational applications for computers in medicine. In fact, since every aspect of medicine must be learned, and since the supply of trained instructors is always in short supply, there will continue to be many opportunities for CAI in medicine. If evaluations, like those described in the first two papers, show marked improvements in learning when applied to newer CAI techniques such as those described in the last two papers, then CAI will assume a major role in the medical curriculum.

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