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Is Hypermedia an Effective Tool for Education?

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Abstract

Whilst there has been much mention in the literature recently concerning the development of hypermedia systems, there is very little reported work on projects to assess their effectiveness, or otherwise, in education. This paper reports on a project currently underway at the University of Southampton in the UK to develop a hypertext interface for an interactive videodisc application in biology education, and to undertake a thorough evaluation of the resulting system as used by undergraduate students at the University. The system is currently based on Apple's Hypercard and uses existing videodisc material.

1 Introduction

Until very recently, the costs of both hardware and software made the use of interactive videodisc (IV) systems virtually non-existent in education. Most examples of interactive video material were in the industrial training sector, where it can be very cost effective as well as educationally effective to produce videodiscs and related software designed for specific training tasks. Such materials are generally very expensive to make and provide no solution to the most effective way of exploiting interactive video in education (Hall, 1988). However, the combination of scope and power provided by the convergence of computing and video technology has the capability to greatly enhance and enrich the learning process in many subject areas. There are numerous areas of education where the only way to really understand or appreciate a concept is to see a photograph or a moving film. Still pictures can be presented in books but no book has the storage capacity of an optical disc; up until quite recently the only way for students to access full-motion video was using videotape as a play-back facility. The ability to access from a single workstation any one of thousands of still pictures, or moving film clips will present new and potentially highly motivating learning environments for many different types of students. Today this is possible with computer controlled laser disc technology. A laser videodisc holds up to 55,000 video frames per side, or approximately 30 minutes of linear playing time. Two audio tracks provide the option of sound and can also be used to s tore digital information. Each of the video frames can be located almost instantaneously giving random access to all the still and moving images stored on the disc. Through software control, the user is no longer a passive watcher of a slide show or a TV programme but is able to interactively determine their own learning path through the video information. This information can be integrated with text and graphics stored digitally, either on the same disc or on the computer, making the potential seemingly limitless.

However, providing easy, interactive access to such large amounts of pictorial information for both authors and readers is a task that will occupy the minds of researchers for many years to come. It is far more complicated to index a picture than a text document, and we need to provide environments in which the links between picture and text and picture and picture appear seamless to the user. Hypertext interfaces appear to offer one possible solution to the latter problem. This paper describes the design and implementation of a hypertext interface for an interactive videodisc system to be used in the teaching of cell biology to undergraduate biology students. The system is based on an existing videodisc that is readily available in Europe, and the Apple Hypercard environment. The paper also presents the first results of an evaluation study that has been undertaken with students using the system.

2 Designing the System

By its very nature, biology is a subject that cannot be learnt or understood without access to pictorial information. Biology text books are always extensively illustrated with line drawings, sketches and photographs. Films and, more recently, videotape recordings are used to illustrate concepts and processes that are dynamic in nature and cannot be easily demonstrated in laboratory sessions. It is therefore natural that biologists should be attracted to videodisc technology as a means of disseminating information about their subject. It was the existence of one such disc (in fact now a series of discs), namely "Cell Biology I: Functional Organisation", that provided the motivation for the project discussed in this paper. The disc is produced by the Institut fur den Wissenschlaftlichen Film (IWF) in Gottingen, West Germany, and is distributed by the British Universities Film and Video Council in the U.K. It is the first in a series of three discs on the general theme of Cell Biology and contains nearly one hundred short film sequences, most with alternative commentaries in English and German (Bereiter-Hahn, Fischer, Hock & Kiermayer, 1984). It provides a video database on the subject it addresses, and can be used in many different ways to explore various aspects of this subject. The material on the disc can be used with different groups of students at many levels and can be adapted to a variety of teaching styles.

The aim of this initial project was to produce software that facilitates access to the information on the disc for first and second year undergraduate biology students, as a complement to various aspects of their cell biology courses. It was necessary that both the software development language and the finished product be easily usable by students and staff unfamiliar with the use of computing technology. It was also envisaged that the first program produced would only use a small portion of the material on the disc and that further programs would be developed in the future. For this reason it was important that the system was flexible enough to be relatively easily extended and up-dated. After initial familiarization with the videodisc, the theme of "Cell Motility" was identified as one which would exploit some of the best images and sequences on the disc yet also remain compatible with key aspects of the first year Cell Biology course offered at Southampton.

The overall aim for the software design was to provide a flexible information presentation system that linked text and graphical information to picture sequences on the disc. The development of guided or 'question and answer' type tutorial material was not a design issue in the initial phase of the project (although it was envisaged that this facility would be added at a later stage). A number of design strategies were considered, including linear sequencing of the material, hierarchical branching and a network approach. The first two of these were quickly rejected as being too inflexible and directed; it was felt that for use in higher education, the system should encourage the user to determine their own way around the information as much as possible. A

network approach, where any one section of the system can be linked to any number of other sections via (generally) bi-directional links, was considered to be the most flexible design strategy, one which would provide the user with a greater degree of interaction with the system.

Of course, this design strategy embodies the concept of non-sequential writing and it is difficult now to disentangle the thought processes that led to the identification of this strategy. At the time of the initial design phase of the project (the autumn term of 1987), the terms hypertext and hypermedia were becoming more and more common in the computer science literature, but were not well-known outside of this. Suffice it to say here that the subject specialists envisaged a network approach for the presentation of information in this integrated and interactive text, graphics and video system, and a hypertext interface seemed to best fit their design criteria.

3 Implementation

Hypertext is the term first used in the early 1960's by Theodore Nelson to describe the idea of non-sequential writing (Nelson, 1967). The reader who is unfamiliar with this idea should refer to the new book by Shneiderman and Kearsley (1989). Basically a hypertext system is one which allows authors and groups of authors to link information together, create paths through related material, annotate existing texts and create notes that point readers to the same or other units of information. The term 'hypermedia' is often used to describe a hypertext system that has been extended to incorporate other media, such as graphics, video or sound, in addition to text. There are a number of such systems under development both in research establishments and the commercial world (Conklin, 1987), but there are as yet very few documented reports of their effective, or otherwise, use in education. One example that has been widely reported is the Intermedia system (Yankelovich, 1988) at Brown University, which has been successfully used to create educational materials in a number of subject areas including English Literature and Biology. Another is the StrathTutor project (Kibby and Mayes, 1989), which is a hypertext system for exploratory learning.

Intermedia has recently become commercially available but in the early part of 1988, when implementation of the project was due to begin, the availability of commercial hypertext systems in the UK was extremely limited; the availability of 'hypermedia' systems even more so. The only commercially available hypertext system was OWL's Guide (Brown 1987), which exists for both the IBM pc and the Macintosh, but at the time, the software hooks to enable Guide to drive a videodisc player were not readily available. However, when Apple released Hypercard at the end of 1987, they also released a set of video drivers that enable a videodisc player to be controlled easily through Hypertalk (the programming language of Hypercard), and this made Hypercard a natural choice for the project at the time. Using Hypertalk and

the appropriate video drivers, it is easy to define a button that, for example, sends a command to the videodisc player to play a particular sequence. The way in which the Hypercard stack was set up to incorporate the video commands and to include various other development utilities is documented in Carr (1988).

Hypercard is not generally classified as a hypertext system. It was built and is used as a graphics prototyping and programming environment. Nielsen (1989) describes Hypercard as computationally active hypertext, clicking a button causes a Hypertalk script to run. Thus the links are not necessarily hardwired and the destination may be computed. It is the ability to easily define the action associated with a button via a Hypertalk script that makes Hypercard such an adaptable environment for the development of multimedia applications. Hypertext-like interfaces can be developed using words and icons, within the text and graphics, as buttons that activate links to other cards, or as references to items stored on other media such as video or sound sequences. The limitations of Hypercard for such applications are well-known. For example, current versions do not support multiple windows or multiple fonts within a text field. However, the ease with which it can be used to develop multimedia applications and the fact that it is freely available on any Macintosh computer make it a very practical choice for education.

The final hardware configuration for each workstation in the project was an Apple MacSE computer connected to a Philips 415 videodisc player via the standard RS232 interface. No genlock board is available for the MacSE so overlay of the computer output on the video screen is not possible. Consequently two monitors are used, one for the computer output and one for the video image, but this is not a significant disadvantage for the purposes of this project because there are many instances where the students need to see a full-size picture in conjunction with text or graphics information on the computer screen. In the future we would like to extend the project to use MacII's and overlay boards to provide greater interaction between the user and the visual information. We also envisage developing applications with multiple video windows and other advanced multimedia concepts. However, we still have much to learn about how students interact with even the simplest type of hypermedia system.

4 The Hypertext Interface

The network on which the original system was based, was designed by the biologists to represent the interconnectivity of the video sequences on the disc identified as being of relevance to the topic of Cell Motility. Details of the biological content of the network can be found in Hall et al (1989). The nodes of the system are cards in the Hypercard stack; these may contain text or graphics information and some of the graphics cards include simple animated sequences to illustrate particular biological concepts in a dynamic

way. A major problem with Hypercard in its current form is the lack of proper scrolling text fields. This forces the author to use continuation cards and to compartmentalise information into card-length packages. This can be very limiting but for educational purposes can be turned to advantage to ensure that the information in the system is not too verbose and is well categorised.

Key-words in the text, or sometimes in a separate icon, are highlighted in bold font to indicate that they are buttons which when clicked will activate a link to another piece of information in the network (text, graphics, animated graphics or video). One major issue that was not addressed in the first implementation of the project, is the problem of identifying for the user of a multimedia environment the type of information that they are about to access when they click on a particular button. It is very frustrating to be launched into a video sequence when you are not really sure this is the information you wanted, or equally to click on a key-word that you assume will provide access to a video sequence but that turns out to be textual information only. There are a number of different approaches to the solution of this problem. Some are possible within Hypercard some are not. The only way such information is available to our users at the moment is on the 'map' of the system (see Fig. 1), which represents the network of nodes and links in the system and indicates which nodes are video sequences and which contain animated graphics. During the first evaluation phase, this map was only available to the user in paper form. In subsequent phases of the project it will also be available as an integrated part of the hypertext system.

Apart from the 'key-word' buttons within the text, the user only has to know about seven specially defined buttons in order to move around the system. These are all shown in the examples given in Fig. 2. There are two 'return' buttons, one returns the user to the last card visited, the other returns the user to the first card in the stack (the initial 'menu' card). Forward and backward arrow buttons are used to indicate further or previous associated information.

Two of the remaining three buttons were introduced to help users navigate around the system: these are the index and the contents buttons. Index and contents lists are well-established tools for helping readers find their way around sequential information and are just as effective for jumping quickly to a particular piece of information in a hypertext system. In this case the index was formed out of the words or phrases that appeared as buttons in the stack, that is the items about which some information is given or for which some cross-reference is made. The contents list was formed out of the titles of each card in the stack. Both were generated automatically using software tools written in Hypertalk and both can be used interactively to locate a particular card in the stack.

The last specially defined button was introduced as a result of comments from students and staff during the implementation phase. They wanted the ability to link the information in the cards (or on the video) to key reference

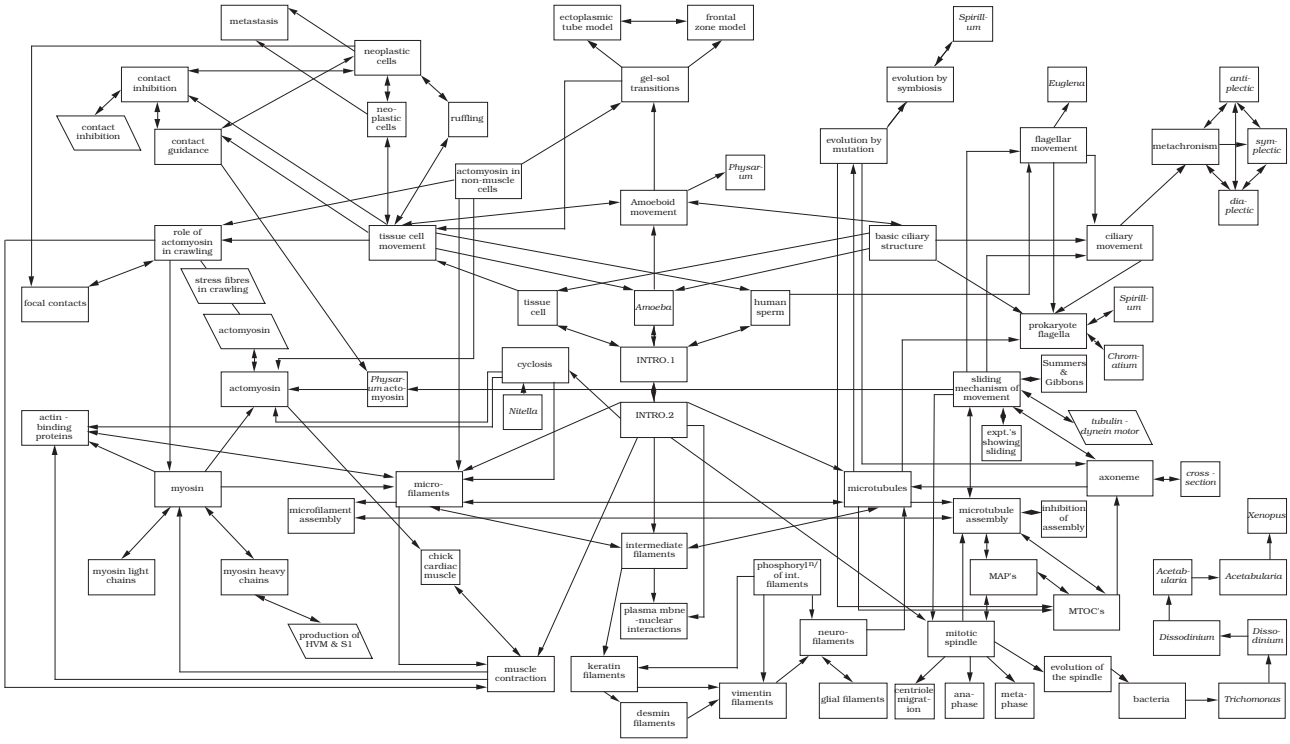

Figure 1: The Cytoskeleton and Cell Motility Map (Reproduced from Hall et al [11], with permission)

Fig. 1: The map of the system (reproduced from Hall et al.)

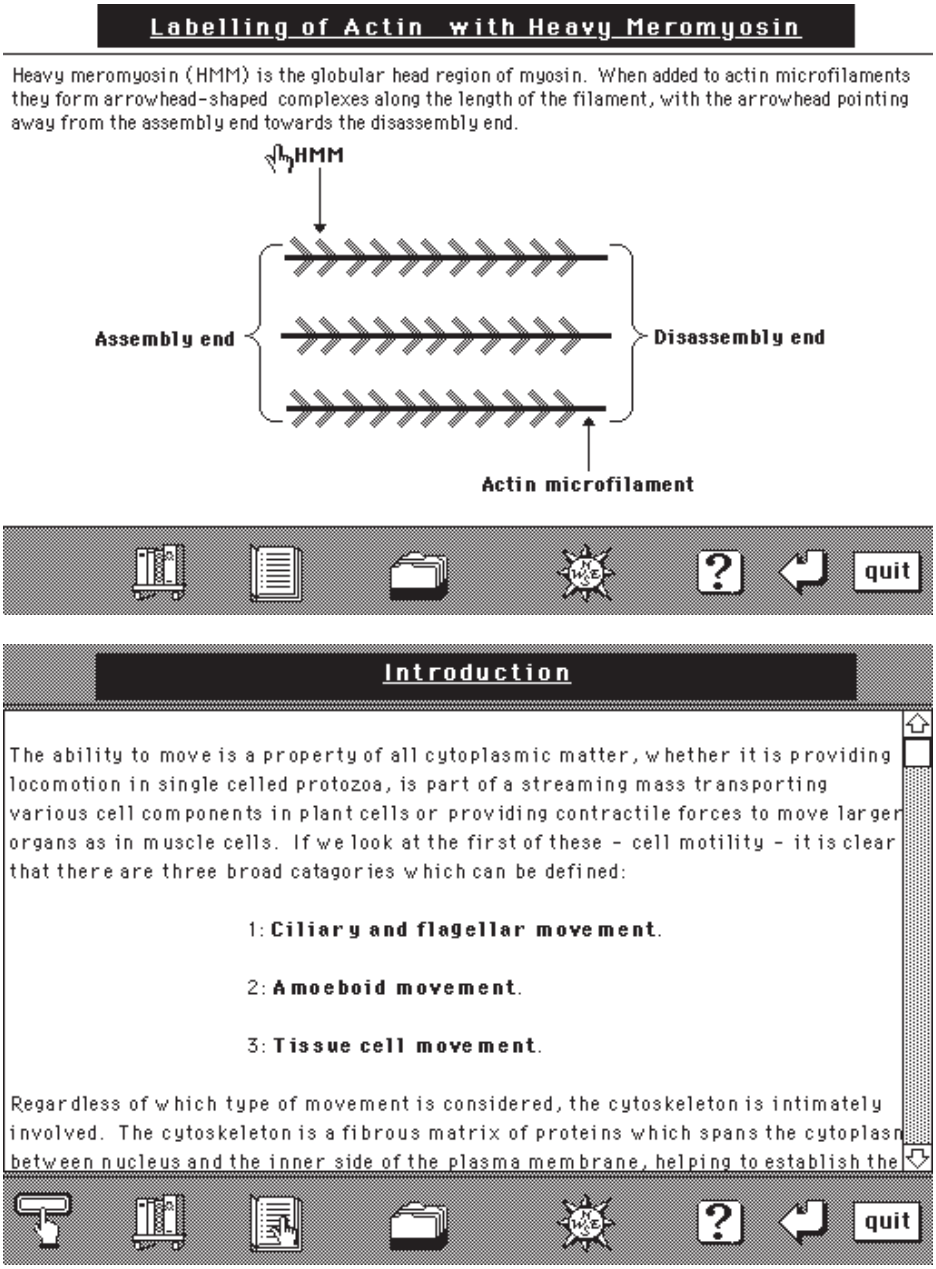

Fig. 2: Example cards from the Cell Motility stack

texts or papers that they might normally use during the study of this subject. This prompted the inclusion of suggested references in a window, which is revealed or hidden by clicking on the reference button. (In an ideal hypertext system, the actual references would be available as part of the system, on a CD-ROM say, but at the moment copyright issues are a major problem to deal with in this context. We plan in the first instance to extend the system to incorporate 'in-house' research papers and lecture notes.)

5 Evaluating the Project

This paper has described a pilot project that utilises Hypercard to implement a hypertext interface for interactive video, in order to create a learning and reference environment for undergraduate biology students. The project has been a great success on a number of different levels, not least in promoting a very fruitful collaboration between the departments of computer science, biology and teaching media. At the very least, the system provides students with access to some excellent video sequences, at best it will help them to learn more about their subject. But how do we evaluate the levels of success or failure of the system in an educational context?

The current version of the system was used during the spring and summer terms of the academic year 1988/89 to complement the first year Cell Biology course. Students attended their normal lecture course but were asked to attend an extra tutorial where they were given information about the system and how to use it. The lecturer concerned also used the videodisc player in some of the early lectures to demonstrate the type of video material available, and suggest ed some introductory routes through the hypertext system that particularly complimented these introductory lectures. For this evaluation period, the system was set-up in one of the student laboratories, which was not on the most convenient site for most of the students. In future years, a dedicated workstation area will be established in the Medical Library.

Only one IV workstation was available for student use during this period. There were 79 students on the course and they were asked to use the system on a reference basis. Booking sheets were available but since the course took place over a ten week period and the amount of material in the Hypercard stack was limited to about 250 cards and about 50 video sequences, there was sufficient time for all the students to have access to the material if they so wished. Use of the system was not a compulsory element of the course.

Each time the students used the system they were asked to fill out a short questionnaire designed to elicit their reactions to the technology, the software and the content, and to record information about the duration of time they spent using the system. In this way we hoped to be able to monitor not only the students' initial reactions but also their changing views as they became more experienced in using the system. Additionally, observations were made of students using the system and a small sample of students were interviewed

in depth.

This evaluation study was designed to provide feedback on how users liked or disliked the program and also to identify particular difficulties that users had in navigating around the stack. It was performed as preparatory work for an extensive three year project for the development and evaluation of software for interactive video in the teaching of cell and developmental biology. No attempt was made to assess the effectiveness of any learning which took place, through pre- and post- testing. Nor was there any direct attempt to compare this mode of learning with others. At the time of writing, the full report of this study is in preparation (Sprunt et al, 1989) but the initial results can be summarised as follows.

A number of lessons were learnt from this initial phase, not least of which was that a voluntary, unsupervised exercise for first year undergraduate students with very full commitments was expecting too much of student enthusiasm and goodwill, no matter how motivating the environment and the software. After a very muted student response to the initial availability of the system, a further briefing session was arranged to encourage more student usage. At the end of the course, a total of 25 questionnaires had been completed and 15 students had been observed and interviewed. Another factor that should be taken into account is that at Southampton there are very few Apple Macintosh computers available on public access and most of the students in this class were unfamiliar with the Macintosh interface. Infact, very few of the students had used a mouse prior to this project and had to develop this skill before they could use the software. The more advanced features of buttons, scrolling fields and 'pop-up' windows also needed prior explanation. In addition to these problems, the students had to learn how to turn the videodisc over when prompted, since both sides of the videodisc are used in the program, and this caused much confusion at first. All these problems will disappear with time as students become more familiar with the technology but they must be taken into account during these intitial studies.

The overall impression gained from observations and interviews with students was that despite the criticisms they articulated, the irritating bugs in the software and the annoying idiosyncrasies of the hardware, neither the quality of the videodisc material and its related text, nor its overall value as a teaching aid was strongly criticised. On the contrary, in the interviews the students conveyed considerable enthusiasm and interest in the medium being evaluated. The quality of the video sequences far outweighed any inconveniences caused by the technical hitches, although students did comment on the unfamiliarity of the structure of this medium compared to the comfort and familiarity of the book. The majority of the students indicated that they would use the system again and would welcome courseware for a wider range of topics.

The questionnaire presented a mixture of positive and negative statements about the program and prompted the student for responses on a 5-point scale.

The 15 statements presented related to the program content, the educational aspects of the program as a whole, the characteristics of the delivery system, and the support provided within the software. For those completing the questionnaire, the responses showed a clear concensus of attitude towards most of the statements. An overwhelming majority of the students found the program to be an effective learning resource and an enjoyable form of instruction. Very few found the technology intimidating and only a small percentage found the two screen display distracting. All those who completed a questionnaire found that having reference titles displayed within the text was a great advantage, and most of them considered the contents list and the index vital for navigating through the text.

However, opinion was divided about problems of disorientation within the program. Of the 25 responses on completed questionnaires, 10 agreed or strongly agreed that it was easy to become disoriented within the program. Whilst the remainder disagreed or had no comment, clearly a significant number of the students had some difficulty in navigating around the information in the stack. It is difficult to tell whether this was due to lack of familiarity with this type of software or whether there are inherent problems in either our hypertext model or hypertext techniques generally.

In order to study the navigation problem and to monitor how the students are using the hypertext interface and the video information, we have developed a software tool that logs each student session on the system. Since any such software tool must contain a model of the system, in order to monitor which nodes are visited in each session and with what frequencies, the same tool can be used to automatically create a map of the system. It has also been extended to enable the author of a tutorial stack to build and display the overall structure map of the field of study showing the topics covered and to link this to the map of cards in the tutorial stack. For follow-up discussion and evaluation, it can be used to display student paths through the structure maps, and to automatically create a display of the total number of times a card or topic is visited as well as a display of the average times spent on each card or topic.

This extremely powerful tool was introduced to monitor student use of the system towards the end of this initial evaluation study and the results will be reported in the final version of this paper. The Hypercard environment was used for prototyping the evaluation tool, but it is already clear that in the final version some of the analytical pre-processing tasks would be better implemented in another language such as C to improve execution times.

In summary, we are extremely encouraged by the very positive response from the students towards their first exposure to a hypermedia system. It was generally perceived by the students as being a useful aid for general revision purposes as they studied for examinations. However, in the next stage of the project we will include material that the students will not have previously seen in lectures and make this a compulsory element of the course. Of course,

further evaluation studies are required to assess the novelty effect of both the videodisc technology and the hypertext interface, and to establish how the latter can be used to best effect in the learning process. Nevertheless, the results from this preliminary study indicate that hypermedia can be usefully applied in an educational context and that it is worthwhile to generate further material for this medium.

6 Conclusions

In this paper we describe the implementation of a hypertext interface in Hypercard to provide access in an educational context to video sequences. We do not claim to have solved the problems of creating and up-dating a generic hypertext/hypermedia system but we are attempting to analyse the advantages and disadvantages of hypertext interfaces for multimedia information systems. Our implementation environment, Hypercard, has its limitations but it does enable quite sophisticated information handling systems to be developed very quickly. The author of the Cell Motility stack was a third year biology student (one of the current authors—GH) with no previous programming experience, who produced a working version of the stack within 10 weeks of first using Hypercard. However, we are not inextricably linked to Hypercard and remain open to changes in the software development environment in the future. Most importantly, all text and graphics produced for the project will be stored in a standard format such as LaTeX or SGML, so that it can be readily adapted for whatever hypertext interface is chosen. Our philosophy in this respect is described in Rahtz et al (1989). This will also enable members of staff to incorporate lecture notes and research papers into the hypertext environment as effortlessly as possible.

Of course, linking this material to video sequences is currently dependent on the availability of suitable videodisc material. This is a serious problem, since making a videodisc is a costly enterprise and with current technology it is not possible to edit the video material created. However, this is no argument for not making the best use of the video material already available and exploring how to use this material to improve teaching and learning. As technology progresses it will become easier to create visual databases, both computer graphics and video based. It will become possible to network these images to personal workstations and we will be able to manipulate pictorial information with the ease that we can manipulate textual information today. Clearly an international effort is called for to create and share visual databases in many different subject areas and for all levels of education. The development of satellite technology will enable us to readily transmit and up-date such information around the world. There are no language barriers to pictorial information.

Even given this utopia, we have to create the software environments that will

allow us and our students to make sense of such vast amounts of information. We have so much to learn about how to design interfaces for the multimedia information systems of the future. Hypermedia techniques may provide us with some of the answers we are looking for.

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