INTERACTIVE MULTI-MEDIA SYSTEM

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ABSTRACT

Increasing systems sophistication and limited personnel resources are dramatically demonstrating the need for cost effective training, operations, and maintenance assistance at the work site. The Interactive Multi-Media System (IMMS) addresses these needs by providing training, technical documentation, and operations information in a highly interactive format using advanced microcomputer and optical videodisc design. IMMS uses Spatial Data Management as a means to provide users with rapid and natural access to varied types of information in an easy-to-use and unified format. There are no languages to learn or typing required with IMMS. Optical videodiscs are used in IMMS to provide users with immediate access to interactive video-based information. Some of the interactive videodisc functions supported by IMMS include diagnostic procedures, step-by-step assembly, maintenance, and operations activities, and technical information support. Other multi-media aspects of IMMS include the use of variable data sources such as microfiche, videotape, remote data systems, and teleconferencing to support changes in technical information and procedures as well as off-site instruction. Finally, embedded subsidiary incentives in IMMS stimulate the learning and usage of IMMS by users.

INTRODUCTION

The productivity limits of our current training technology may have been reached. Massive efforts to improve "stand-up" lectures, printed training materials, and "hands-on" laboratory experience have begun to yield too few significant returns. We need revolutionary new techniques that will break through the constraints posed by existing training technologies and allow us to beat the current tradeoffs that must be made among costs, quantity and quality. Videodisc technology is one of the most promising sources of these new techniques.

Videodisc technology is creating opportunities for new kinds and forms of training devices at surprisingly low cost. At the heart of this technology is the capability to access tens of thousands of color images, including stereo sound, in seconds of fractions thereof. When coupled with the new uniquitous microprocessor, videodisc technology offers new opportunities for training applications as well as new issues for the training specialist.

In this paper we share some of our ideas and experiences in the application of IMMS to training. Specifically, we will examine three new ideas for training applications which use videodisc technology. We then consider issues relevant to these applications and their implications for training. We begin a brief review of the characteristics and capabilities of the optical videodisc.

OPTICAL VIDEODISC TECHNOLOGY

A videodisc is similar to an audio record except that each side of a 12-inch disc contains 30 minutes of television. Since television is the rapid presentation of pictures at a rate of 30 images per second, each side of a videodisc contains 54,000 still pictures in color.

The player for a videodisc is much like a turntable except that under computer control the player can rapidly find any particular part of the videodisc. Specifically, any one of the 54,000 images, or any part of the 30 minutes of television on a videodisc, can be located typically in a fraction of a second. A videodisc provides a combination of moving and still images, any part of which can be quickly located.

Videodiscs are made like audio records using original materials that can be movies, videotapes, pages of text, tables of numbers, graphs, charts, maps, drawings, diagrams, or photographs. From the original materials, a master disc is produced that in turn is used to "press" multiple copies speedily and at low cost.

Three types of videodiscs and videodisc players are now available. The players are characterized by the market they are targeted for: general consumer usage and industrial/educational applications. Various potential manufacturers such as JVC, IBM, Xerox, Zenith, to name a few, are waiting in the wings, but only six are now marketing videodisc players.

- Magnavox, a wholly owned subsidiary of Philips, began selling a consumer model player for about $800 in December 1978.
- Discovision (DVA), under license by MCA, began general sales of an industrial player for about $3,000 in June 1979.

- Thompson-CSF began sales of an industrial player for about $3,500 early in 1980.

- Pioneer began sales of a consumer player for about $700 late in 1980.

- RCA began sales of their consumer videodisc player early in 1981.

- Sony began limited sales of an industrial videodisc player in mid-1981.

Some of the aforementioned companies have announced marketing plans for their videodisc systems. Matsushita (which markets under brand names such as JVC, Panasonic, and National) and several other Japanese companies have announced marketing dates of first quarter 1982 for their consumer videodisc systems.

The differences between consumer and industrial systems are significant as Table I shows. *For instructional settings, the industrial* players incorporate microprocessor control for fast random access, pre-programmed branching, and frame selection. Microprocessors have also been installed in the less expensive consumer players to provide random access, branching, and frame selection. However, the servo-mechanism in these players requires from 15 to 20 seconds to locate a frame in the worst case. Maximum access times for the industrial players are under four seconds. The consumer players lend themselves to instructional application, but the functional capabilities of the industrial players may be sufficiently greater than their higher cost is justified. With experience, we should discover what various videodisc features buy in terms of instructional achievement and will thereby be able to recommend commercial or industrial players depending on instructional settings.

laser focused on the track and thereby generate a signal that is processed and passed to a standard video monitor (i.e., to the antenna terminals of a TV set).

One video frame is stored on each track and there are 54,000 tracks per disc. Video, audio, and still photographic information can all be intermingled on these discs. These videodisc systems effectively provide rapid access to 30 minutes of video information, 30 minutes of analogue audio information, 54,000 still photographs, well in excess of 400 hours of digitized audio information, 30 minutes of motion picture information, or various combinations of the above. The point to be made is that videodiscs provide rapid random access to a lot of information which can be inexpensively stored and replicated. Table II presents a summary comparison of the videodiscs discussed in this section.

There are at least two important differences *between the DVA/Sony/Philips and the Thompson-CSF* videodisc systems. First, the Thompson Disc is "transmissive" while the others are "reflective". Light from a laser passes through the Thompson-CSF disc and is picked up on the other side. On a DVA, Sony, or Philips system, the disc reflects light back up so that light is sent from and received on the same side of the disc. Three implications of this difference in technical approach are: (1) the Thompson-CSF disc is "floppy", it can be rolled up in magazines and newspapers, and the reflective disc is rigid; (2) by adjusting the focus of the laser, either side of the Thompson-CSF disc can be read without physically turning the disc over. If both sides of the reflective disc are to be used, it must be physically turned over-- or there must be a light source for each side; and (3) the Thompson-CSF disc is more sensitive to dust and dirt than the reflective disc.

Features	Consumer Players	Industrial/Educational Players
Cost	$800	$2500-$3500
Still frame	Manual or automatic	Manual or programmed*
Frame random access	Manual Visual idensitication	Manual or programmed Visual, keyboard selection, or programmed
Frame-by-frame "stepping"	Manual	Manual or programmed
Variable speed motion (forward or reverse)	Manual	Manual or programmed
Two discrete sound channels	Yes	Yes

*Programmed control may be through an on-board video disc player microprocessor or an external computer.

Table I. Comparison of Consumer With Industrial Video Discs

With the exception of the RCA system, the videodisc players discussed above are all optical, laser-based systems. They use a 12-inch disc with a spiral track. The track is pitted with oblong depressions or micropits about 1 micron deep that vary in accordance with the audio or video information they represent. During playback the disc spins at 1,800 revolutions per minute while these micropits modulate a low power helium-neon

The second important difference between the two discs is that the Thompson-CSF disc systems observe European PAL/SECAM television standards as well as U.S. standard NTSC. The reflective disc observes only American NTSC television standards. When used in PAL/SECAM mode, the Thompson-CSF disc therefore provides more lines per display. The major instructional implication of this difference seems to be that because of the better resolution

	Magnavox/Phillips	Discovision DVA	Thompson-CSF
Cost	$800	$2,600	$3,500
Market	Consumer	Industrial/Educational	Industrial/Educational
Cost of Master	$1,500[a]	$1,500[a]	$1,500[a]
Cost of Copies	$5-$10[c]	$5-$10[c]	$18[b]
Technology	Optical-reflective (two-sided aluminum disc)	Optical-reflective (sided aluminum disc)	Optical-transmissive (two-sided plastic disc)
Standard	NTSC	NTSC	NTSC, PAL/SECAM

[a] Cost per side

[b] Cost includes $1.00 for protective plastic cover

[c] Depends on quantity.

Table II. Summary Comparison of Three Video Disc Systems

with PAL/SECAM standards, programs that display large amounts of text may be better suited to the Thompson disc. On the other hand, if instruction designers want to take advantage of the millions of already purchased television sets in American homes, schools, and industries, they may be well advised to use NTSC encoded videodiscs.

__Second Generation Disc Technology__

Two second generation developments in videodisc technology appear to be particularly notable for instructional applications.

First is the anticipated appearance of direct read after write, or DRAW, technology. The important aspects of the DRAW disc is that it stores 10^{10}-10^{12} bits of digital information on __each__ side of the disc. This development is being undertaken by both RCA and Phillips. In the near term, videodisc systems using DRAW technology are likely to be very expensive. However, DRAW disc systems may be better suited for the small volume experimental development that is characteristic of many instructional settings.

Second is the development of still frame sound. All currently available disc systems only provide sound when the disc is played at 30 frames per second. Unfortunately, this detracts considerably from the disc's instructional value during slide-type presentations. DVA and Sony have both indicated that some form of compressed audio providing 3 to 30 seconds of sound per frame is under development.

__Videodisc Versus Videotape__

A brief comparison of videotape capabilities with those of videodiscs may be in order at this point. After all, videotapes represent a rapidly maturing technology, and they can offer many of the features of videodiscs such as random access, variable speed play, and reverse motion. Three points appear to be salient:

1. Tapes can be edited and current videodiscs cannot. This difference is likely to be removed with the appearance of the DRAW technology discussed above. DRAW technology will, of course, provide editable videodiscs quickly and relatively inexpensively.

2. Random access to arbitrary points on a videodisc is much faster than similar access using videotape. Random access on industrial videodiscs is less than 4 seconds compared with 20-100 seconds on videotape. Moreover, accuracy of random access on videotape leaves something to be desired.

3. Still frames are possible using either videodisc or videotape, but it is exceedingly expensive and cumbersome on videotape and single stepping through a series of still frames is essentially impossible. A far more comprehensive and detailed comparison of videotape and videodisc has been prepared by Heuston (2).

APPLICATIONS OF IMMS TO TRAINING

One of the most exciting aspects of IMMS is that it makes possible an entirely new set of training experiences. This section describes such new applications ranging from new kinds of training movies to low-cost simulators.

__Interactive Movies__

Interactive Movies, illustrated in Figure 1, translate movie viewing into an active participatory process. In effect, the viewer becomes the director and controls many features of the movie. A sampling of feature controls available to the viewer is the following:

1. Perspective. The movie can be seen from different directions. In effect, the viewer can "walk around" ongoing action in the movie or view it from above or below.

2. Detail. The viewer can "zoom in" to see selected, detailed aspects of the ongoing action or can "back off" to gain more perspective on the action and simultaneous activity elsewhere.

3. Level of instruction. In some cases, the ongoing action may be too rich in detail or it may include too much irrelevant detail. The viewer can hear more or less about the ongoing process by so instructing the Interactive Movie System.

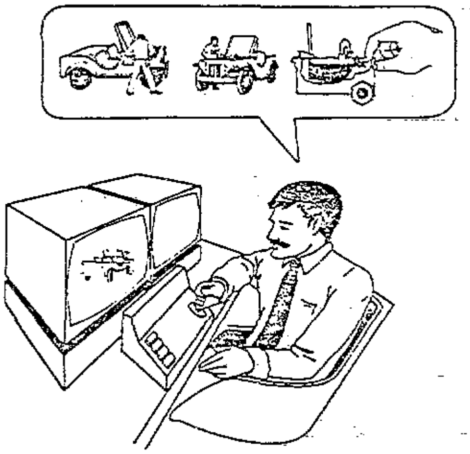

Fig. 1. Illustration of an Interactive Movie.

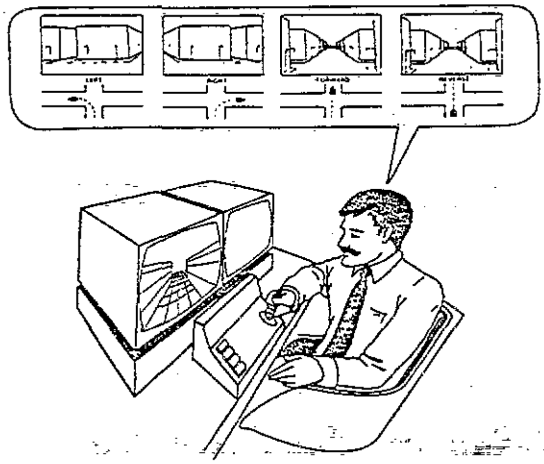

Fig. 2. Illustration of Surrogate Travel.

4. Level of abstraction. In some instances the viewer may wish to see the process being described in an entirely different form. For example, the viewer might choose to see an animated line drawing of an engine's operation to get a clearer understanding of what is going on. In some cases, elements being shown in the line drawings may be invisible in the ongoing action-- for instance, electrons or force fields can be shown.

5. Speed. Viewers can, of course, view the ongoing action at a wide continuous range of speed-- including reverse action and no action (still frame).

6. Plot. Viewers can change the "plot" to see the results of different decisions made at selected times during the movie.

A typical application for Interactive Movies would be in training (and aiding) equipment technicians. The technician could not only see how a particular part is located and installed from several points of view (e.g. top versus bottom) but could interactively control how detailed a description is either seen or heard regarding that maintenance activity.

Several Interactive Movie videodiscs have been completed using hand to hand combat (i.e., karate) as the subject area. These discs let the viewer not only control playing a particular karate move backward and forward at any rate, but also include multiple views and closeup views following every move from four different positions. In progress are several Interactive Movies that focus on equipment maintenance tasks.

Surrogate Travel

Surrogate Travel, illustrated in Figure 2, forms a new approach to local familiarization and low cost trainers. The basic principle is simple. On videodiscs are stored up to 108,000 images showing discontinuous motion along a large number of paths in an area. Under microprocessor control, the user accesses different sections of the disc, simulating movement over the selected path.

The user sees with photographic realism the area of interest. Unlike a travel movie, the user is able to both choose the path and control the speed of advance through the area using simple controls. The videodisc frames the viewer sees originate as filmed views to what one would actually see in the area. To allow coverage of very large areas, the frames are taken at periodic intervals that may range from every foot inside a building, to every ten feet down a city street, to hundreds of feet in a large open area (e.g., a harbor).

The rate of frame playback, which is the number of times each video is displayed before the next frame is shown, determines the apparent speed of travel. Free choice in what routes may be taken is obtained by filming all possible paths in the area as well as all possible turns through all intersections. While it might first appear that this would be a time consuming and expensive technology, it is in fact relatively efficient because of the design of special equipment and procedures for doing the filming.

Demonstrations of this technology have been developed for building interiors (MIT, National Gallery of Art), a small town (Aspen, Colorado), an indusrial facility (nuclear power plant), a weapon site, and San Francisco Harbor. In progress is the production of a prototype video mapping library of broader scope for selected areas worldwide.

To provide training in reading and understanding maps, the photograph-based Surrogate Travel is linked to different sorts of maps of the area. In effect, the viewer can travel across a map, can fly into it getting greater and greater detail from what can be presented by standard map symbology, and then "fall through" the map to see photographically what the map depicts. In addition, the viewer can switch among different types of maps (e.g., topographic, infrared, etc.) to develop an understanding of how different map symbologies and representations interact.

In addition to ground level travel, including the inside and outside of buildings, aerial flight experience can be produced and used for flight training and airport familiarization. Similarly, other forms of travel experience, such as anchorage piloting and low level nap of the earth flying, are also easily accomodated.

Surrogate travel can also be used to provide training on routine and emergency procedures, *physical plant maintenance*, safety, security as well as other training requirements found in ships, military and industrial facilities. In these applications blueprints, floor plans, procedures, and up-to-date reference materials are linked with the photography of the site to provide a powerful and easy-to-use training system.

Electronic Libraries

Electronic libraries, illustrated in Figure 3, in the form of Spatial Data Management Systems (SDMS) provide students and instructors with quick and easy access to an assortment of multi-source and multi-media information (3). Users literally "fly over" information and select what they want by simply pointing. Spatiality is use to group materials into lesson plans so that different information spaces represent course concepts, additional instruction, and assessment procedures.

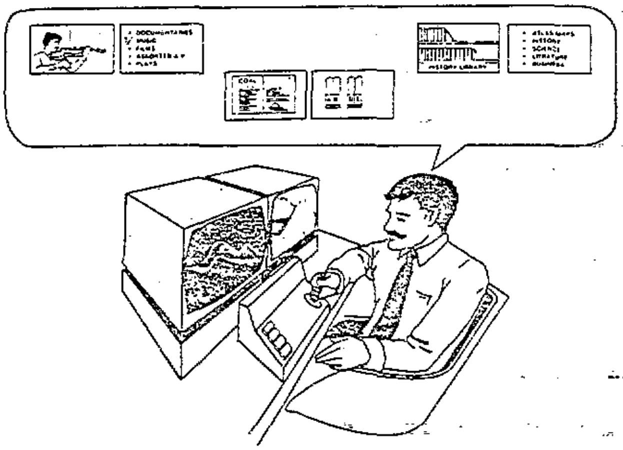

Fig. 3. Illustration of an Electronic Library.

Stored on a videodisc are tens of thousands of frames consisting of photographs, diagrams, charts, texts, movies, spoken speeches, music, graphs, etc. The pages can be organized, reassembled, segmented, and/or duplicated in accordance with the user's need and growing sophistication with the subject matter. The pages can be annotated, highlighted, drawn-on, underlined, etc., at the user's convenience and pleasure.

For the instructor, the SDMS provides ready access to a wealth of material which might otherwise be unaccessible. Instructors can access the SDMS to create their own information spaces (i.e., courses or lectures) and subsequently present such materials to large audiences in single locations via large screen television projection or to multiple locations through cable distribution systems.

Students can independently use the SDMS for self paced instruction by either working through previously designed information spaces or by browsing on their own. When students and instructors are in remote locations, offsite instruction is facilitated by linking two or more SDMSs together using regular telephone lines. In this manner, a student or instructor can literally fly the other to a topic of interest, sharing at geographically remote sites a large library of information.

The same video materials can be used for hundreds of different users. The only thing that must be changed from user to user is the magnetic storage medium which serves as the user's private librarian for the videodisc.

The U.S. Marine Corps Education Center is using the videodisc and SDMS technology to create the electronic library which we have discussed. The low cost replication characteristics of the videodisc make this medium an attractive alternative for the distribution of previously archived information.

ISSUES

Development and use of training applications employing the videodisc such as those discussed in the previous section raise a set of issues to be considered by the training community. A few of these issues are briefly discussed below:

1. What are the authoring requirements in producing videodisc based training systems? Probably the most important requirement is the need to work freely with the capability of storing and almost instantaneously accessing over 50,000 frames of information. Our experience is that many videodisc first-timers make only incremental use of the technology because they do not take advantage of its random access characteristics. Missing from the videodisc milieu are inexpensive authoring systems that would enable authors to put together and try out new videodisc program concepts. Bunderson and Campbell (1) have prepared a more complete discussion of this issue.

2. What is the role of digitized sound and synthesized speech in videodisc applications? Currently, several groups are experimenting with a number of means to overcome the lack of still sound in videodisc systems. Future videodisc systems will almost certainly incorporate still sound capabilities. However, synthesized speech may have an important place in videodisc applications given the rapid, random access capabilities of videodiscs. For example, in the Surrogate Travel application discussed earlier, the controlling computer also generates narrative descriptions that accompany the viewer's travel. Speech synthesis is used as the audio channel because it is not reasonable to prestore all things that could be said for all possible routes that the viewer might take.

3. How does videodisc technology affect the accessibility of training devices? A lot. With the videodisc, the training device designer gets a comparatively low cost (potentially less than $1,000) system that brings together an array of media (slides, text, graphs, movies, sound) in a compact and robust form. In some instances, very expensive computer graphics based systems may be replaced by inexpensive videodisc players.

4. How "smart" a videodisc training device is needed? Smart, yes, but not brilliant. The applications discussed earlier all use videodisc players controlled by small, inexpensive microcomputers. Future videodisc players may incorporate sufficiently capable microprocesor systems to allow the necessary functions to be

completely on board. While it is true that the players available today include a small microprocessor which can support branched instruction-- usage in this mode is far removed from the real potential of the videodisc as a training device.

5. How can training take advantage of the "super realism" offered by videodiscs? In the Surrogate Travel and low cost trainer applications, the viewer sees the real place (e.g., a real tank and, if appropriate, a real explosion). This is all made possible by *storing a fascimile version of events and* materials on the video disc. Thus, instead of seeing a simplification (although at times this may be beneficial), the user interacts with the object or process as it will be encountered in the work place.

6. Are videodisc training devices inherently "fun"? Stated in another form, since television is fun, will videodisc training devices find greater acceptance? Without attempting a full analysis we state our experience: Users enjoy working with these systems. We cannot say if this is because the systems are well designed, because they include color, sound, and motion, because they are a familiar medium (television), or because of something else. Nonetheless, the overwhelming impression we and others have gained from working with videodisc systems is that users like them.

The list of issues above is in no way complete. What we have attempted to do is alert the reader to some of the questions which have arisen through our own experiences. We feel that the area of videodisc based training devices is extremely promising and deserves considerable attention by the training community.

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